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REPORT

OF THE

GEOLOGICAL SURVEY OF OHIO.

VOLUME II.

GEOLOGY AND PALÆONTOLOGY.

PART II. PALÆONTOLOGY.

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PREFACE.

AT the time of the publication of the first volume of the Palæontology of Ohio it was supposed that all the new material collected by the Survey not there described would be included in the present volume, but in the interval so much has been discovered that claimed a place in our Report that it has been thought best to prepare a third volume on Palæontology, to accompany the third volume on Geology, already authorized. This will be offered as Part II. of Volume III. of our Report, and should its publication be ordered it will give a completeness and symmetry to the records of the Survey which they would lack without it.

With this proposed volume, the entire series of reports will consist four volumes, of two parts each, or practically of eight volumes, of nearly uniform size, viz., three on Geology, three on Palæontology, one on Economic Geology, and one on Zoology, Botany, and Agriculture.

The matter which will compose the third volume on Palæontology is, briefly, as follows:

1. A general review of the Fossil Plants found in Ohio, with descriptions of many new species.

A large number of fossil fruits, and a few fossil plants, were described and figured in our first volume, and a remarkably interesting though isolated group of Lower Carboniferous plants will be found described by Prof. Andrews in this volume, but no systematic review of our fossil flora has yet been given to the public, and the greater number, and the most interesting of the new species collected on the Survey, are as yet undescribed. These are mostly from the Carboniferous rocks, but they also include marine plants from the Lower and Upper Silurian, the Devonian and Waverly, and also our oldest land plants, the tree-ferns and Araucarian pines, which grew on the Cincinnati island when it was surrounded by the Devonian sea.

This review of the Fossil Plants has the general scope of that on Fossil Fishes given in Vol. I., and includes not only a catalogue of the old and descriptions of the new species, but a sketch of the progress of plant life, so far as it is known, from the most ancient to modern forms.

A place was assigned to this memoir in the present volume, but it could not have been added to the matter now published without making the volume too large for convenience or symmetry with its predecessor, and without carrying its cost considerably beyond the amount appropriated for its publication.

It could not have been preferred in a choice of material without excluding much that is of equal value, and that which had been prepared with the assurance that it should appear in this volume. It was unavoidable, therefore, that its publication should be deferred.

2. A memoir by Prof. O. C. Marsh, on the large Wild Hog, or Peccary (*Dicotyles compressus*), which once roamed through the forests of Ohio, but is now entirely extinct. As was mentioned in the preceding volume, a few disjointed fragments of the bony structure of this interesting animal were the only traces of its existence known before the discovery of twelve nearly complete skeletons in the banks of the Olentangy, at Columbus. It is highly desirable, therefore, that this ample material should be made the basis of a monograph, in which the oldest, largest, and least known species of this peculiarly American type of hogs should not only be rehabilitated, but should be brought into relations with its physical surroundings and the other animals of the fauna to which it belonged. No data have hitherto been known from which the natural history of this animal could be written, but with the special fitness of Prof. Marsh for the duty, and the abundant material that can be placed in his hands, he will prepare a memoir that will become a classic in comparative anatomy, and will add greatly to the interest of our reports.

3. Prof. Marsh has also consented to review all the relics that have been found of our ancient giant beaver (*Castoroides Ohioensis*), and prepare a more complete and accurate description of it than has yet been written. It will be remembered that the first traces of this creature were

found in the excavation of the Ohio Canal, at Nashport, and it was brought to the notice of the scientific world by the late Col. J. W. Foster, when connected with the first geological survey of the State. Perhaps no other of our extinct animals has excited a deeper interest than this one, and nothing that could be published in our palæontological reports would be read with greater avidity than any new information in regard to *Castoroides*.

4. Our reports would also be glaringly incomplete if they should fail to contain some notice of the elephant, the mastodon, the horse, the musk-ox, the reindeer, the bison, true oxen, and other large mammals, the remains of which have been found in our State. Some of these remains have never been seen by any comparative anatomist, and none of them have been carefully studied. Prof. Marsh has consented to examine this material—which, though scattered and rapidly disappearing, is still considerable in quantity—and we may confidently anticipate that in his hands it will form the basis of a very interesting chapter in our ancient history.

5. A considerable number of new species of invertebrate fossils still remain in our hands for description. These are chiefly Mollusks from the various formations of our geological scale. Many of them have been already studied, and it only remains to have descriptions and drawings of them made to bring the Palæontology of Ohio in all departments up to date. It is hoped that this material also will form part of Volume III.

Among the special reports which form the present volume, it will be seen there is one by Prof. H. A. Nicholson, now of the University of St. Andrews, Scotland, on our Silurian and Devonian Corals. It is only an act of justice to state that this report was written and the drawings which illustrate it were made by Prof. Nicholson himself on the eve of his departure for Europe, when his time was peculiarly precious to him, and that both report and drawings were furnished without compensation.

The plates, which form so important a part of this volume, were lithographed by Messrs. T. Sinclair & Son, of Philadelphia, and Strobridge & Co., of Cincinnati—the Mollusks, Crustaceans, and Salamanders by the

former, the Plants and Fishes by the latter. Both these firms deserve our sincere thanks, not only for the good quality of their work, but for the courtesy and patience with which they co-operated in all efforts to secure a creditable result.

The Amphibians offered peculiar difficulties to the lithographers. They were drawn on stone directly from the fossils, and as the color of these were jet black, like the matrix, and their forms were discernible only by a practiced eye, the fair degree of success attained in their delineation deserves special praise.

J. S. N.

GEOLOGICAL SURVEY OF OHIO.

VOL. II. PART II.

PALÆONTOLOGY.

DESCRIPTIONS OF FOSSIL FISHES.

BY

J. S. NEWBERRY.

FISHES OF THE DEVONIAN SYSTEM.

GANOIDEI.

PLACODERMI

GENUS DINICHTHYS, Newb.

SINCE the publication of the first volume of this Report, a large amount of interesting material, illustrating the structure of this genus, has been brought to light. In this material is to be found nearly the entire bony system of one large individual, which gives us a more complete representation of *Dinichthys* than has yet been obtained of any of the larger fossil fishes of the Old World. These specimens we owe to the enthusiasm and intelligence of Mr. Jay Terrell, who found them at his home in Sheffield, Lorain Co. Here the upper portion of the Huron shale forms, along the Lake Shore, cliffs, which are being constantly worn away by the waves. These cliffs have been Mr. Terrell's favorite hunting ground, and as the erosion of the surface revealed here and there the projecting point of a bone, each indication has been followed up with care, and the bone taken out, perhaps in many fragments, but yet complete in all its parts. Mr. Terrell has carefully preserved and united these fragments, and thus has been able to contribute to science some of the most interesting and valuable paleontological material ever discovered. Some months since, while scanning the cliffs near his house, his attention was attracted to a bone of which only a small portion was visible, the remainder being concealed in the rock. On taking this out, others immediately associated with it were revealed, which were, however, so deeply buried, as to be inaccessible by ordinary means. In these circumstances Mr. Terrell began operations on a shoulder of the cliff immediately above, and excavated a space about twelve feet square down to the locality of the bones. Here he found the ventral shield, before unknown, quite complete; one perfect mandible, a "premaxillary," and two "maxillaries;" a perfect dorsal shield, two feet in diameter; two scapulo-coracoids, with a large number of additional bones, including the ossified rays of a large fin. From the same locality Mr. Terrell had before obtained a cranium almost complete, and two Supra-

scapulas, thus giving us, as has been said, nearly the entire bony structure.

Since this important discovery, Mr. Terrell has found a complete mandible and maxillary of larger size than any before met with; the mandible being twenty-two inches in length.

From this rich array of material we get not only much additional light in regard to the structure of *Dinichthys*, but are furnished with the means for accurately defining the two known species of the genus. It also shows that some errors were committed, from confounding the two species, in writing the descriptions contained in Vol. I.

When the main portion of that volume was written, neither maxillary nor mandible had been found on the Lake Shore, and all the bones of *Dinichthys* collected at Sheffield, Monroeville, and Delaware, had been grouped together under one specific name.

In a foot note appended to the description of *Dinichthys* on page 322 of Vol. I., Part II., is mentioned the discovery at Sheffield, by Prof. A. A. Wright, of a mandible quite different from those found at Delaware. This evidently belonged to a new species, to which the name *Dinichthys Terrelli* was then attached. The large number of specimens since obtained, and, indeed, all the remains of *Dinichthys* hitherto taken from the summit of the Huron shale at Sheffield, belong, as we now know, to this species, which is quite distinct from that found at the base of the formation at Delaware. Hence the Dorsal plate figured on Plate 32, the Cranium on Plate 33, and the Supra-scapulas on Plate 34, Vol. I., should be credited to *Dinichthys Terrelli* rather than to *D. Hertzeri*, with which they were formerly and erroneously connected. The details of structure in which the species differ, will be given further on.

The study of the specimens, the discovery of which has been described, has resulted not only in a better knowledge of the anatomy of *Dinichthys*, but has revealed some interesting things in regard to the relations of this genus to living and fossil fishes; all of which will be briefly referred to in the pages which follow.

The most striking feature of *Dinichthys*, apart from its great size, is its dentition, of which we have now all the parts. In this the most conspicuous elements are the massive mandibles, of which the posterior extremities are rounded and flattened, and were evidently connected with cartilaginous articular portions. The anterior end of each mandible is turned up to form a strong, acute, and prominent tooth. Behind this the jaw is thickened by a ridge on the inside, which usually terminates above in a triangular, tooth-like projection. The upper margin of the mandible, for five or six inches behind this projection, is compressed, and consists of remarkably dense, enamel-like bone. In *D. Hertzeri* this is produced

into a row of conical teeth, about half an inch in length. In *D. Terrelli*, on the contrary, the margin of the mandible here forms a sharp cutting edge. At the posterior end of this edge it is sometimes obscurely crenulated by what are evidently rudimentary teeth, the dwarfed and abortive homologues of those which occupy the margins of the maxillaries and mandibles of *D. Hertzeri*.

The dentition of the upper jaw consists of what I have called, for convenience in my description, premaxillaries and maxillaries, without, however, intending to commit myself fully to this view of their homologies.* These have been partially described in the notice of *Dinichthys* contained in Vol. I., Part II., of this Report, but new material has made it possible to give a fuller description of them now.

Beginning at the anterior extremity of the head, the muzzle is terminated by two large, triangular "premaxillaries," of which the upper sides are flattened and concave, while the opposite angles project downward to form great, incisor-like teeth. These interlock with and shut over the projecting points of the turned up mandibles, which are received into their concavities.

Behind the premaxillaries, two oblong dental plates or *maxillæ* are set directly over the prominent, denticulated, or cutting edges of the mandible. In *D. Hertzeri* the *maxillæ* are somewhat irregular in outline, the lower margins being the longer and set with teeth similar to and interlocking with those of the mandible below. In *D. Terrelli* the maxillaries are oblong or quadrangular, with rounded angles, and the lower edges are sharp and knife-like, and overlap and play upon the sharp edges of the mandibles.

When we compare this peculiar dentition with that of other fishes, we find that *Coccosteus* among fossil, and *Lepidosiren* among living fishes, offer some remarkable and suggestive points of resemblance.

The dentition of *Coccosteus* will be referred to further on in connection with some other anatomical features which it has in common with *Dinich-*

* In describing these bones I have called them premaxillaries and maxillaries, because they hold the positions and perform the functions of these organs in other fishes. We have not yet found the anterior and upper portions of the head so well preserved that its structure can all be made out, and we can only be *certain* of the homologies of the bones in question when we shall have obtained more, and more perfect, material. One head of *D. Hertzeri*, found at Delaware by Mr. Hertzer, shows the "premaxillaries" and "maxillaries" in position, but the interior of the head is not visible. As will be shown further on, the dentition of *Dinichthys* corresponds very closely with that of *Lepidosiren*, but even with full proof of identity of structure in the dentition of these genera, the question before us would hardly be cleared of doubt, as what Professor Owen calls maxillaries in *Lepidosiren*, Professor Huxley calls, probably with good reason, palato-pterygoid dental plates.

thys, but it may be said here, in passing, that it is on the same general plan with that of *Dinichthys*, and, in some respects, is strikingly similar to that of *D. Hertzeri*.

Comparing *Dinichthys* and *Lepidosiren*, a surprising similarity is at once apparent, and it may be said that the dentition of *Dinichthys Terrelli* is almost exactly like that of *Lepidosiren annectens*, except that it is more than a hundred times larger.

This similarity is well shown in the subjoined wood-cuts, which represent the dentition of both, one of the size of nature, and the other about one-tenth the natural size, linear.

DENTITION OF *LEPIDOSIREN ANNECTENS*, OWEN.



Front and side views of head, natural size, drawn from specimen.

From these figures it will be seen that the dentition of *Lepidosiren* consists of mandibles which have almost the exact form of those of *Dinichthys Terrelli*, and have the same structure and functions. In *Lepidosiren* the anterior extremity of each mandible rises into a prominent tooth, while, behind this, the upper margin presents, first, a ridge or fold, which produces a subordinate denticle, and then, for about one-third the length of the mandible, is a sharp edge of enamel. At its posterior end this is slightly denticulated, as though with rudimentary teeth, as in *Dinichthys*. In the upper jaw we find two dental plates, more or less perfectly joined at the symphysis, and forming, first, by a strong anterior fold on either side, prominences which are functional teeth, and which match the produced extremities of the mandibles. Behind these, on each side, is a second ridge or fold, and then a wing-like plate of enameled bone, which plays upon the corresponding edge of the mandible. The most cursory examination of the figures and descriptions of the dentition of *Dinichthys* will show that it corresponds closely to this pattern.

In *Lepidosiren* there are also two small, pointed teeth ("nasal," Owen; "vomarine," Huxley) which overhang and precede the dentition that has been described. No teeth corresponding to these have been discovered with the remains of *Dinichthys*, but this is not strange, for even if the

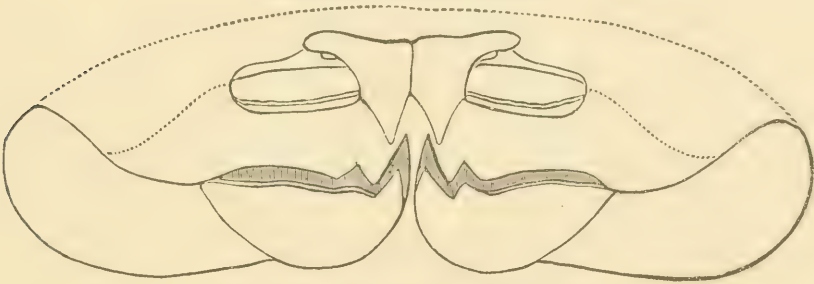
DENTITION OF DINICHTHYS TERRELLI, N.



Side view, one-tenth natural size, linear.

correspondence in dentition had been made exact by the existence in *Dinichthys* of parts homologous to these, they would probably have been easily separated from the cranium, as they are in *Lepidosiren*, and would be quite sure not to be found in position.

DENTITION OF DINICHTHYS TERRELLI.



Front view (diagram) one-tenth natural size, linear.

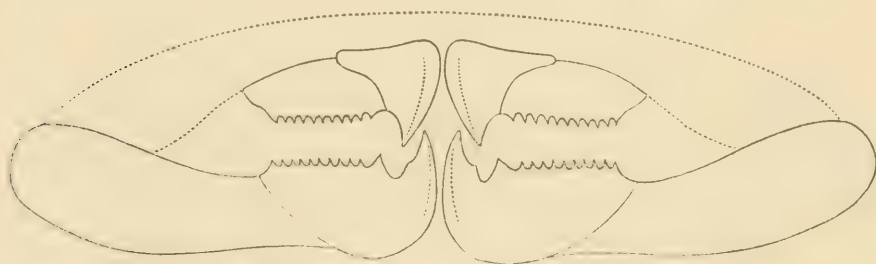
Professor Theodore Gill, the distinguished zoologist, who has examined my specimens of *Dinichthys*, while recognizing the great similarity existing between the dentition of this genus and that of *Lepidosiren*, and accepting my view of their close zoological relationship, is inclined to consider the great anterior "teeth" of *Dinichthys* as homologous with the small pair of nasal or vomerine teeth of *Lepidosiren*. The reason which he gives for this opinion, is the separation in *Dinichthys* of the parts which I have called premaxillaries and maxillaries, while in *Lepidosiren* the dental apparatus of the upper jaw consists of a single, though folded

plate on either side.* This seems to me, however, a less important feature than he regards it, and the argument used to sustain the view cited above, viz.: that "teeth never coalesce," is hardly supported by facts. Even if true, it could have no bearing on this question, as the organs under discussion cannot be accurately called teeth.

Among the bones of the head in fishes, we find a very wide range of variation, in number, size, position, and mode of union, and this where the homologies can be clearly made out. Now we must suppose each phase of variation to be the result of a special creation, or that the various modifications are derived one from the other. The teeth of fishes are far more variable than the bones proper, and many instances might be cited in which the diversity of size, number, and form of the teeth has apparently resulted from fission or union. A good illustration of this is seen in the genus *Cochliodus*, where some of the species differ mainly in this, that in one (e. g., *C. contortus*) the scroll-like teeth are composed of several rings, set side by side, while in others (as *C. nobilis*), they are united in a solid cylinder. Perhaps a still better example is afforded by the genera *Dipterus* and *Heliodus*. These are closely allied, and they are of special interest in this connection, as they are the ancient representatives of the group of Dipnoans to which the Australian Barramunda (*Ceratodus Forsteri*) belongs. In *Dipterus*, there are two triangular fanlike teeth set on the palato-ptyergoid bones. These are in contact by the longer of the sides which inclose the right angle, but are not united. In *Heliodus*, these two teeth are completely fused into one (see Plate LVIII., Figs. 15-18).

Where the general plan of dentition is so distinctly preserved, as it is through phases of variations similar to those mentioned above, it is impossible to resist the conclusion that these phases have had a common origin.

DENTITION OF DINICHTHYS HERTZERI.



Front view (diagram) one-tenth natural size, linear.

The question of the homologies of the "premaxillaries" of *Dinichthys*—

i. e., whether they are the homologues of the anterior, vomerine teeth of *Lepidosiren*, or whether they represent the anterior folds of the great "palatopterygoid" dental plates, separated from their maxilla-like wings,—though one of interest, does not materially affect the greater question of the general relationship of *Dinichthys* to *Lepidosiren*. The minor question will doubtless be settled in due time by the discovery of some specimen in an unusual state of preservation. The broader and more important one, it seems to me, may be decided from the material now before us.

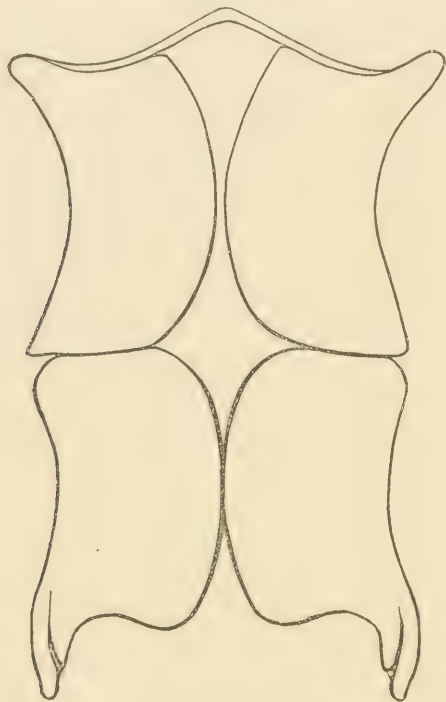
Whatever may be said in regard to the dentition of the upper jaw, the peculiar mandibles of *Lepidosiren* and *Dinichthys* are so alike in every essential particular that they would seem to afford evidence of relationship, even if all other proof was wanting. On the whole, the correspondence between the dentition of *Dinichthys* and *Lepidosiren* is so remarkably close that it seems to afford good ground for believing that we have in the latter the dwarfed and diminished representative of the great group of fishes which, in the Devonian age, populated and dominated the waters of the globe; and that the peculiar dentition of *Lepidosiren* is a remnant of an antique fashion once much in vogue but now obsolete, except as preserved in this little living Dipnoan. The proof of relationship between *Dinichthys* and *Lepidosiren* seems to be at least as satisfactory as that of *Ceratodus Forsteri* of Australia with *Ceratodus* of the Trias, *Ctenodus* of the Carboniferous, and *Dipterus* of the Devonian; and if the view here presented should be accepted, the facts cited will, perhaps, not be regarded as less important and suggestive than those connected with the discovery of a living species of *Ceratodus*.

The relations of *Dinichthys* to other fossil fishes, as revealed by the series of specimens found during the past year, are no less interesting than those which this great fish bears to the living *Lepidosiren*. The most striking specimens obtained by Mr. Terrell are the bones composing the ventro-pectoral and dorsal shields; both of which are almost entirely complete. These are so perfectly represented in the figures now published (Charts V. and VI.—natural size, from photographs) that no detailed description of them will be required. The large view given of the pectoral and ventral bones represents their inner surfaces, and they are somewhat separated in order that their outlines may be more clearly shown. In the subjoined wood-cut, however, they are represented (one-tenth natural size, linear) in their natural positions, as seen from the outside.

By comparing this plastron—if we may so call it—of *Dinichthys*, with that of *Coccosteus*, which is also given below in outline, it will be seen that they correspond in all essential particulars; so much so that the bones which compose them might be taken to be the homologous parts in different species of the same genus. It is true that the ventral shield of *Coccosteus*,

as described and figured by Pander and Owen, consists of six pieces; the central rhomboidal plate ("ventro-median") being detached from the

VENTRAL SHIELD OF DINICHTHYS TERRELLI, N.



One-tenth natural size.

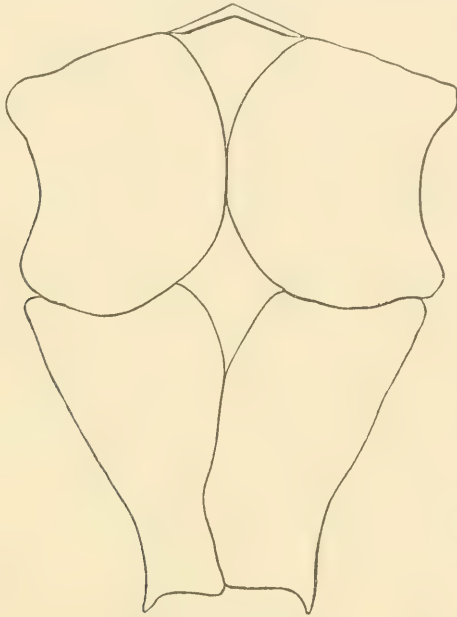
triangular plate which forms the middle of the anterior margin ("pre-ventro-median"). In *Dinichthys*, these two bones, having almost exactly the same form, are united by a narrow bony band. It is almost certain also that they were connected in *Coccosteus*, though it is possible that the isthmus that united them was cartilaginous. The union of these bones is plainly seen in Pander's figures (*Ueber die Placodermen des Devonischen Systems*. Taf. 5, Fig. 1, No. 13.)

The anterior pair of lateral plates (*pre-ventro-laterals* of Owen) are relatively longer and narrower in *Dinichthys* than in *Coccosteus*, and their anterior angles are more prominent; but these differences are of trifling import. The anterior margin of these plates, as well as that of the *pre-ventro-median* is strongly reflexed. This character is indicated by a double line, and is common to the plastrons of both the genera under consideration.

The posterior lateral plates (*post-ventro-laterals* of Owen) are broader

and somewhat more rounded in outline in *Dinichthys* than in *Coccosteus*, but less so than might be inferred from the figures; as in that of the plas-

VENTRAL SHIELD OF COCCOSTEUS DECIPIENS, AGASS.



Natural size : after Pander.

tron of *Coccosteus*—which is taken from Pander's restoration—the posterior lateral plates are represented as overlapped by the anterior laterals, and thus their anterior margins are concealed. One of these plates is also made by Pander in his restoration to overlap the other, and the posterior end of the plastron is thereby much narrowed. What evidence of such overlapping he had does not appear, as no indications of it are seen in his figures of the fossils themselves, either the individual plates, or the groups in which they are shown. The posterior lateral angles of the hinder pair of ventral plates are produced in both *Dinichthys* and *Coccosteus*, but much more so in the former than in the latter. In *Dinichthys* this portion of the plate is greatly thickened, and its interior face is excavated in a deep longitudinal furrow, which must have served to hold and protect the nerves and blood-vessels that passed out to the ventral fins. This furrow is shown in the figures of the post-ventro-lateral plates, which are given, of the natural size, on Chart VI.*

* I have elsewhere called attention to the fact that in position and form these bones correspond so closely with the pubic bones of *Plesiosaurus* as to suggest homology with them. It will also be noticed that the anterior pair of ventral plates offer us striking

The remarkable correspondence between the ventral shields of *Dinichthys* and *Coccosteus* will probably be accepted without argument as evidence of consanguinity, even though the cephalic and dorsal shields should seem quite unlike. In fact, however, the differences in the armament of the upper part of the body of the two genera are those of degree rather than of kind, and are much less important than would appear at first sight. They will be referred to again on another page.

The relationship of *Dinichthys* and *Coccosteus* is also indicated by similarities of dentition. The jaws and teeth of *Coccosteus* are not yet perfectly known, but Pander has figured the mandibles, and has given some indication of the dentition of the upper jaw; or at least has given figures which show that the premaxillaries (?) were united in one piece, which was set with small, pointed teeth. In all the specimens, figured and described by Pander, the anterior extremities of the mandibles seem to have been defective, and we have yet to learn precisely how they were united. In the middle portion of each mandible there is seen a row of teeth formed by the prolongation of the jaw-tissue, precisely as in *Dinichthys Hertzeri*. In the specimens represented in the figure cited above, in addition to the view given of the under side of the ventral plates, the posterior extremities of both mandibles are distinctly shown. These are flattened and spatulate, precisely as in *Dinichthys*. Unfortunately the anterior extremities are broken away; the mutilation of the specimen depriving us of information that would be peculiarly precious in this connection. Many other fragments of the mandibles of *Coccosteus* are figured by Pander, but none supply us the data necessary for a complete comparison with those of *Dinichthys*. We are, however, justified in saying that the dentition, as a whole, was very similar in the two genera.

When now we come to consider the bones of the cranium and the dorsal shields, we find some marked differences between those of *Coccosteus* and *Dinichthys*. In *Coccosteus* the cranial bones form a nearly circular, solidly cemented, and highly ornamented cephalic shield, to which the dorsal carapace is supposed to have been firmly united. In regard to this latter point there is some doubt, for the articulation of the "suprascapular bones" with the posterior lateral angles of the head is such as to indicate considerable freedom of motion; and I am led to believe that the body plates were disconnected with the head except by this articula-

resemblance to the coracoids of *Plesiosaurus*. In the present state of our knowledge it would doubtless be safer to consider these resemblances those of anologous rather than homologous bones, but for reasons which will be given further on, it seems to me not impossible that we have in the plastron of *Dinichthys* elements of both the pectoral and pelvic arches, here more highly developed than in any living fishes, and presenting Amphibian and even Reptilian characters.

tion, as we know was the case in *Dinichthys*. The different plates of the body buckler in *Coccosteus* are usually supposed to have been somewhat firmly united. By Agassiz, Pander, Miller, and Owen, they are represented as being all soldered together, but as they were plainly united by splint joints—the margins in some instances greatly overlapping, and the component bones separating so easily that they are usually found disconnected—we are compelled to believe that they were less firmly joined than the head bones.

The Supra-Scapulas (Post-Temporals of Parker) of *Coccosteus* are very much like those of *Dinichthys*; being similar in form, and having a corresponding articulation with the angle of the head. The only noticeable difference in this articulation in the two genera is the thumb-like process thrown out from the epiotic(?) bone, to strengthen it, in *Dinichthys*. This is wanting in *Coccosteus*, but the linear furrows forming the large-figured ornamentation, described elsewhere, is visible on the "Post-Temporals" and Epiotics(?) of both genera.* The "Post-Temporals" of *Chelyophorus* are still more like those of *Dinichthys*; scarcely differing in any respect, except in size.

In the present volume are published figures of the dorsal shield of *Coccosteus*, from American and Scotch specimens; and the dorsal shield of *Dinichthys* is represented on one of the large plates (Chart V.) which accompany this report. From the figures on this chart, all of which are of the natural size, a comparison may be readily made, and it will be seen at a glance that the difference is considerable. That the bones under consideration are homologous, there can be no reasonable doubt; but we must turn to another group of Placoderms to find dorsal shields like that of *Dinichthys*. These we meet with in *Asterolepis* and *Heterostius*, especially the latter. The dorsal shield of *Asterolepis* is the bone described by Hugh Miller as a hyoid plate. Pander, however, places it in its true position, on the back, immediately behind the head. By reference to the figures given on Plate 8 of his work, cited above, it will be seen that in all essential points of structure the dorsal shields of *Heteros-*

* The bone of fishes, called the *Supra-Scapula* by Cuvier, and by most zoologists since his time, is asserted by Mr. W. K. Parker to be the *Post-Temporal*, and since the oblong quadrangular bone which is articulated by a very perfect and movable joint with the head in *Coccosteus* is named the Supra-Scapula by Prof. Huxley, Mr. Parker calls that also the Post-Temporal. While not prepared to deny the accuracy of this view of an anatomist so deservedly distinguished as Mr. Parker, I venture to ask for this case a rehearing, and the consideration of the suggestion that this bone, so entirely independent genetically from the cranium, belongs to a posterior vertebral arch; and that it is either what it has been called, the Supra-Scapula, or still better, the Supra-Clavicle. With this interpretation, the bone with which it articulates, and which forms the posterior lateral angle of the head would be the Post-Temporal.

tius and *Dinichthys* are the same; the only difference being that in *Heterostius* this bone is much shorter than broad, while in *Dinichthys* the two diameters are nearly equal.

The cranium of *Dinichthys* seems also to approach more nearly in structure to those of *Asterolepis* and *Heterostius* than to that of *Coccosteus*. The resemblance would also seem to be somewhat closer with *Heterostius* than with *Asterolepis*. In the latter genus the occipital portion of the cranium forms nearly a straight, transverse line, while in *Heterostius* it is very much arched, as in *Dinichthys*. The posterior margin of the supra-occipital plate—which forms the center of the arch—has nearly the same character in *Dinichthys* and *Heterostius*, that is, it is impressed with two deep pits separated by a narrow ridge, and behind these is a peculiar pyramidal projection. All the bones of the hinder part of the head in *Dinichthys* are usually found soldered firmly together, the union between the Supra-occipital and the Epiotics being so firm that their points of junction cannot be discerned, and they seem to form one solid bone. This bone is, however, sometimes found disarticulated, and it is figured on Plate LIX.

The anterior portion of the head is generally dismembered, and seems to have consisted of strong bony plates lined with and more or less firmly united by cartilage, as in *Heterostius* and *Asterolepis*.

The outer surfaces of the external bones of *Dinichthys* are marked with a fine granular, almost imperceptible ornamentation. In addition to this, the cranial surface is inscribed with a series of excavated lines which form an ornamental pattern, of which the outlines have not yet been fully made out. Something of the sort is discernible on the crania of nearly all the Placoderms. It may also be seen on the Post-Temporals ("Supra-Scapulas"), and in *Dinichthys* and *Coccosteus* traces of it are visible on the bones of the plastron.

There is this marked difference, however, between *Dinichthys* and its congeners, *Asterolepis*, *Heterostius*, *Coccosteus*, *Pterichthys*, *Aspidichthys*, etc., that they all have the surfaces of their external plates ornamented with thickly-set and often prominent and stellate tubercles, while the surface bones of *Dinichthys* show only the granulation and linear furrows referred to above.

In one instance the anterior part of the head has been found entire, but this was in a concretion, and it was so much injured by the removal of its hard and tough matrix, that the outlines of the plates composing it cannot be discerned. This shows, however, that a sheet of bone covered the entire surface of the head. In all the crania found at Sheffield, the muzzle has disappeared; only the occipital and central portions remaining. The brain-box was apparently partly bone and part cartilage; as we find,

anterior to the bony arches which strengthen the occipital portion, a depressed area (as seen from the inner side), where some flat radiately-striated bones are crushed up against the roof of the skull. Possibly the brain was completely encased in bone, but the obscure and confused appearance of the under side of the cranium has led me to infer that a considerable portion of the original structure was cartilage.

Two detached cranial bones found with the head, by Mr. Terrell, and referred to on another page, evidently correspond with those figured by Hugh Miller and Pander, as belonging to the anterior part of the head of *Asterolepis*, and partially inclosing the eye-orbits.

A pair of large bones, not before met with, formed part of the great skeleton of *Dinichthys*, quarried out at Sheffield last year, by Mr. Terrell. They are nearly two feet in length, at one end somewhat fan-shaped, flat, and about seven inches wide, at the other narrow and bifurcate. These would be called Coraco-scapular bones by Gill, Coracoids by Owen and Gunther, and Clavicles by Parker. They will be referred to again in the notes on *Dinichthys Terrelli*.

The fins of *Dinichthys* are only made known to us by a single fragment, six inches long by three or four wide. This is apparently a portion of a median fin, of which the rays are as thick as one's little finger, and well ossified. Several large flat plates have been found associated with the bones described above, but their places are not yet fully determined. They will be noticed more at length in the description of *D. Terrelli*.

From the foregoing remarks it will be seen that the discovery of *Dinichthys* is a matter of interest, not simply because it adds another and the most gigantic to a strange, extinct group of fishes, but also because it serves as a connecting link between several genera of Devonian Placoderms, of which the affinities have been somewhat obscure, viz.: *Coccosteus* and *Pterichthys* with *Asterolepis* and *Heterostius*; and more especially because it shows a relationship to exist between these peculiar fishes and the anomalous living *Lepidosiren*.

The finding of a living species of *Ceratodus* (*C. Forsteri*) and its careful study by Dr. Gunther, have apparently resulted in tracing a genetic line from *Dipterus* of the Devonian, through *Otenodus* of the Carboniferous, and *Ceratodus* of the Trias, to one marked form of living Dipnoans. From what we have seen of the resemblance in structure between *Lepidosiren* and *Dinichthys*, we may conclude that a parallel line ran upward from the Devonian Placoderms to the other living branch of the Dipnoan family, now represented by *Lepidosiren* and *Protopterus*. The links in this chain have not yet been found, but there is little doubt that they will hereafter be discovered.

It is an interesting fact that the living Dipnoans are inhabitants of the Southern Hemisphere, while the living Ganoids (as formerly defined) are found only in the rivers of the continents lying north of the Equator. This difference of geographical distribution, and the differences noticeable in their anatomical structure, have led zoologists to place the Dipnoans and Ganoids in distinct orders; but Dr. Gunther proposes to unite them in the order *Ganoidei*. The recent discoveries that have been alluded to, seem to confirm this classification, by tracing the living Dipnoans back to the Ganoids of the Palæozoic ages, which then occupied both hemispheres, and formed the most powerful and highly organized living beings.

The relationship which has been shown to exist between the Devonian Ganoids and the modern Dipnoans suggests the question of the relative grade of these ancient fishes; for it is well known that the living Dipnoans, from several points in their structure, and especially from the possession of a three-chambered heart, and both lungs and gills, have been regarded, first, as amphibians, and afterwards, as the highest order of fishes. The terms high and low in classification, have been somewhat vaguely employed, and have created much misapprehension. They are certainly not expressive of the true relationship between the synthetic or *generalized* types of ancient times, and the more *specialized* of the present. The modern Teleost is undoubtedly a more perfect *fish* than any of the so-called fishes of the Palæozoic ages, although the latter include in their structure certain points which link them more closely with the higher classes, the *Amphibia* and *Reptilia*. In one aspect, therefore,—their relationship to the higher groups—the earlier fishes were higher in the scale than the more modern, but in other respects they were more rudimentary in structure, for the vertebral column and brain-box were in them cartilaginous, while in modern fishes they are ossified. The fact seems to be simply this, that the great group of Ganoid fishes, which led and gave character to the fauna of the Devonian age, formed the parent stock from which, by differentiation, the fishes have branched off on one side, the amphibians and reptiles on another. In a tree the lower branches may bear only leaves, and in that respect are but one step in advance of the trunk, while the higher branches bear flowers and fruit; but both are outgrowths from the trunk, and fibres, reaching down from each, blend there; so that the trunk—low in position and function as it is—has more in common with the branches which bear respectively the vegetative and reproductive organs, than they have with each other.

The mingling of amphibian and ichthyic characters in the ancient fishes is readily explained—and we may say, can only be explained—by supposing them to have formed the common stem from which both fishes

and salamanders have branched. In this original stock the characters of all the derived groups are to be found, though in an imperfectly developed state. Our modern fishes, for the most part, belong to the group called osseous fishes, because they have complete bony skeletons, but in the ancient fishes the quantity of dense bony tissue which formed their exoskeletons exceeded many times the quantity of bone in the modern fishes, and it was apparently in structure more like the bones of amphibians and reptiles than like the bone-tissue of fishes. Joined to this extreme development of external bone was the cartilaginous vertebral column, which was a mark of embryonic and rudimentary development. It is evident, therefore, that the quantity and the perfection of bone tissue is no safe guide in the classification of fishes. The massive bones of *Dinichthys* are very impressive, not only from their magnitude, but from their density and perfect preservation. None of the bones of reptiles or mammals would have been, under the circumstances, more completely unaffected by the influences that have surrounded them. In this respect they are evidently superior to the soft and elastic bony tissue which forms the skeletons of most, and the highest, modern fishes. We are compelled, however, to regard the complete and impenetrable armor, and the massive and formidable jaws of the great Placoderms, as heavy and rude first models, rather than the light, elegant, and efficient machines which are the perfected results of a long process of improvement. The heavy armor worn by the knights of old has long since been laid aside, for the mail-clad warriors of the middle ages would be clumsy and powerless antagonists to our light-armed troops, carrying repeating rifles and revolvers, and moving with the celerity and precision of modern tactics. So in the progress of ichthyic life, increased intelligence, rapidity of movement and address, have proved in the struggle of life more than a match for the impenetrable but cumbrous defenses of the sluggish and over-loaded Placoderms.

Facts of like import may be found in the life-history of all classes of animals, and those not less real and suggestive in the history of man and the progress of civilization.

In a note appended to a preceding page, I have called attention to another point in the structure of *Dinichthys* which may possibly show a relationship between the Placoderms and the Teleost fishes, and it may even be with the higher classes of Vertebrates. This subject is one of such interest that I venture to again call attention to it. By reference to the figures now given of the ventro-pectoral shield of *Dinichthys*, it will be seen to be composed of two pairs of flattened bones, which apparently held some relations with the pectoral and abdominal fins. This is clearly shown with regard to the posterior pair by the deeply excavated furrows.

which mark their posterior lateral angles. Every anatomist will recognize the probability that these furrows served for the reception of nerves and blood vessels which passed to the posterior members. When, now, we compare this shield with corresponding or analogous parts in other animals, we find some remarkable and suggestive resemblances :

1st. The elements of the ventral shield of *Dinichthys* offer a striking parallel with the flattened bones which compose the lower parts of the pectoral and pelvic arches in *Plesiosaurus*, viz., the coracoids, the interclavicular (or sternal) cartilage, and the pubic bones. It is quite certain that the bones of each series held corresponding positions and performed, more or less perfectly, the same functions, and it has seemed to me not impossible that they are homologous. In this view the anterior lateral bones of the shield would be considered as coracoids, the posterior pair as pubic bones, and the median plate as the equivalent of a sternum, and, perhaps, an interclavicle.

The notion that the paired bones of the plastron of *Dinichthys* can be the representatives of the coracoids and pubic bones of reptiles will at first sight appear so heterodox as hardly to deserve a second thought, and the view that they are simply dermal ossifications, like the scutes of the sturgeon, the dorsal plates of the Siluroids, etc., will seem much more simple and satisfactory.

It would certainly be an easy way of explaining the origin of these plates, to suppose them to form one of the almost infinitely varied phases assumed by the exoskeleton of fishes, but it often happens that the easy and simple explanations of Nature's problems are not the true ones, and, as will be shown further on, reasons may be found for seriously doubting that these bones form any part of the exoskeleton.

2d. In the turtles the under side of the body is defended by a plastron which performs the same functions and resembles much in character the ventral shield of *Dinichthys*. Yet it will be noticed that there are important differences between them. The plastron of the Chelonians usually consists of four pairs of plates, with a wedge-shaped intermediate one in front. All of these are claimed, and are apparently shown, by Rathke, to be membrane bones developed in the integuments, and having no connection with the endoskeleton. The anterior three bones of the plastron of the turtle are thought by Huxley to correspond to the three gular plates of the Labyrinthodont Amphibians and to be the representatives of the clavicles and an interclavicle.

The two pairs of bones which compose the central and chief portion of the plastron of the turtle, hold the positions of the two pairs in the shield of *Dinichthys*, and some turtles possess those which are not greatly unlike them in form. It is, therefore, not impossible that they are their equiva-

lents; but the Chelonian plastron consists of nine bones, while there are only five in that of *Dinichthys*. Of these five the anterior three correspond more closely in position with the anterior three of the turtle's ventral shield, and have better claims to be considered their equivalents than have the second pair to be regarded as the homologues of the second pair, in the shield of the turtle. The hinder pair of plates in the plastron of *Dinichthys* are much more free and independent than the second pair of the turtle's shield, and have much less the character of dermal scutes, and more that of internal bones. Still farther the posterior pair of the turtle's plates (Xiphoplastrons) are, so far as we know, entirely absent from the plastron of *Dinichthys*. It is perhaps possible that the as yet unlocated plates of the under side of the body of *Dinichthys*, described in the notes on *D. Terrelli*, may have been so associated with those of the plastron as to give the ventral armor more similarity to that of the turtles than it now seems to have, but in the present state of our knowledge the differences seem to be not only great but radical.

3d. The characteristic gular plates of some Amphibians (*Archægosaurus*, etc.) have been referred to as offering some similarity to the anterior three bones of the plastron of *Dinichthys*.

These Amphibian throat-plates consist of a rhomboidal median one, with a pair somewhat triangular in outline, converging forward and united with the median plate by its antero-lateral margins. Von Meyer considers these plates as homologous with the anterior plates of the plastron of the turtles, while Owen compares them with the jugular plates of *Megalichthys* and *Sudis*. By Prof. Huxley they are regarded as clavicles and an interclavicle. Taken by themselves, the anterior three bones of the plastron of *Dinichthys* are not very unlike, in form and position, the gular plates of Amphibians, but we must know more of the plates which protected the throat of *Dinichthys*, before we can make the comparison satisfactorily. Possibly the homologues of the Amphibian gular plates, if any existed in *Dinichthys*, were placed quite anterior to the plastron. However that may be, the posterior pair of plates of *Dinichthys* are without any representatives in the shield of *Archægosaurus*; a difference so important as to throw doubt over any suggestion of homology.

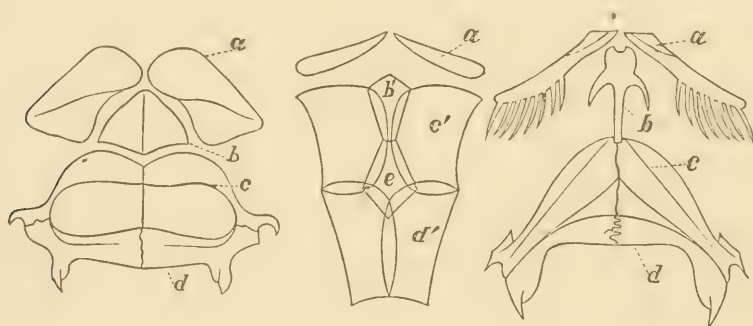
4th. Prof. Huxley, in his admirable memoir, "On the Classification of Devonian Fishes," * compares the sternal shield of *Coccosteus* with those of some existing Siluroid fishes—*Clarias*, *Loricaria*, etc.—and finds such correspondence in these parts, as well as in the cranial plates and dorsal armor, that he suggests a genetic relationship between the ancient Placo-

* Memoir of the Geological Survey of the United Kingdom, Decade X.

derms and the modern Siluroids. Prof. Owen had previously called attention to this resemblance,* though rather to explain the function of the plate armor of the Placoderms, than to prove a zoological affinity. In fact this resemblance is in many respects very striking; so much so that it is difficult to believe that it is simply "homoplastic," and not "homogenetic." Assuming the theory that our modern Fishes, as well as Amphibians and Reptiles, are derived from a common ichthyic stock, it is not illogical to suppose that the characters of that ancient stock have been divided among their descendants, one line taking one, and another, another of the most striking features, and handing them down as heirlooms through generation after generation. The plate armor of the ancient fishes doubtless served a very useful purpose, and there has probably never been, in the history of fishes, a "piping time of peace," when they could all "lay their armor down," but some tribes have constantly worn it, either in the old time-honored and well-tried patterns, or modified to suit changed circumstances.

Thus it may very well be that the plate armor of the old Placoderms has become the heritage of the Siluroids, and they have retained little beside; while the dentition and much of the internal structure have been preserved by the far more old-fashioned fishes, the *Dipnoi*.

In Professor Huxley's memoir "On the Classification of Devonian Fishes," outline figures are given of the pectoral shields of *Coccosteus*, *Clarias*, and *Loricaria*, which are reproduced below.



CLARIAS.

COCCOSTEUS.

LORICARIA.

a a a, Hyoid bones. *b b' b*, Urohyals. *c c' c*, "Coracoids." *d d' d*, "Radii."

From the text which accompanies these figures the following passages are quoted:

"On comparing this apparatus with the sternal shield of *Coccosteus*, one is tempted to compare the antero-median piece of the latter with the urohyal of the Siluroid, the antero-lateral piece with the 'coracoid,' and

* Palæontology, Second Edition, p. 148.

the postero-lateral piece with the so-called 'radius,' the more especially as the antero-lateral piece corresponds with that part of the thoracic shield of *Pterichthys* which supports the plated appendage representing the pectoral fin in that genus.

"On the other hand, it must be confessed that the closer connection of the antero-median piece with the thoracic plates than with the hyoidean cornua, and the very backward position of the postero-lateral plates, apparently out of reach of any connection with the fins, militate against this view; which, in addition, leaves the median rhomboidal plate unaccounted for.

"In the Siluroids to which I have referred (*Clarias*, *Bagrus*, *Arius*, etc.) and in *Loricaria*, a vast latero-ventral shield is produced by the prodigious expansion and coalescence of the bony elements which are homologous with those termed 'coracoid' and 'radius' in other fishes.

"Viewed from the ventral surface, these bones form four great plates, those of each side being closely united, or even amalgamated together, while the opposite pairs are joined in the middle line by a strongly serrated suture.

"When the pectoral fin is provided with an anterior spine, this is articulated by a curiously complicated joint with the so-called coracoid. The cornua of the hyoid are large stout bones, and the urohyal, also a large and strong bone, which is particularly broad in *Loricaria*, connects the hyoidean with the pectoral apparatus."

Mr. W. Kitchen Parker, in his "Monograph on the Shoulder-Girdle" (p. 23, *et seq.*), discusses, with much learning and ability, the homologies of the pectoral shields of the Siluroids and that of *Coccosteus*, but does not fully adopt the suggestion of Prof. Huxley in regard to these. By him the bones of *Clarias* and *Loricaria*, marked *c* and *d* in the above woodcut, are considered to be, respectively, clavicles and interclavicles, while the anterior pair of plates of the ventral shield of *Coccosteus* (marked *c'* in the figures), he regards as interclavicles, and considers them as the counterparts of the lowest bone in the shoulder-girdle of the sturgeon. Of the posterior pair of plates in *Coccosteus*, he says: "The bones lettered *d'* may either belong to the post-clavicular cincture, or they may answer, in their sub-cutaneous portion, to the second pair of interclavicular bones of the *Lophobranchii* (*Hippocampus*, *Syngnathus*, etc.)." He says, further: "The keystone pieces (*b'e* of figures) are the exact counterparts of the first two abdominal line plates of the *Lophobranchii*."

From the almost complete identity of structure in the ventral shields of *Coccosteus* and *Dinichthys*, the questions here raised are of special interest in the study of the latter genus; and, whatever conclusion shall be reached in regard to one, will equally affect the other.

As I have remarked on a preceding page, before the homologies of the anterior three plates of the ventral shield of *Dinichthys* can be accurately determined, we must know something more than we now do of the other elements of the shoulder-girdle in this genus. First of all, the homology and relations of the great bones, which I have called scapulo-coracoids, must be ascertained. These evidently correspond wholly, or in part, to the so-called coracoids of *Polypterus* (C of Prof. Huxley's diagram, "Classification of Devonian Ganoids," p. 22, Fig. 17), and many other fishes; and probably to the "Clavicles" in Parker's diagram of the shoulder-girdle of *Lepidosiren*.^{*} How these bones terminate below, whether in an epicoracoid cartilage, or in interclavicular plates anterior to the ventro-pectoral shield, we have not yet learned, but must ascertain before we can fully reconstruct the shoulder-girdle. In the absence of proof to the contrary, we may accept, provisionally, the view of Parker that the antero-lateral plates of the shield of *Coccosteus* (and hence of *Dinichthys*) are the homologues of the broad, bony plates which form the basal supports of the pectoral fins in the sturgeon, and those which meet to complete the pectoral arch in *Gasterosteus*, the interclavicles of *Calamichthys*, etc. In all these cases, however, there are no median plates in the pectoral shield, and, to find this element, Parker sends us to the Lophobranchs, where, in the "abdominal line plates," he sees the exact counterparts of the median bones of the shield of *Coccosteus*. It seems to me, however, that this version of the homologies of the plates of the plastron of the great extinct Placoderms cannot be strongly insisted on, though it would be difficult to disprove it. The plastron of *Dinichthys*, for example, composed of but five, large and ponderous, bony plates, is so simple and symmetrical that the effort to find its homologues among the multitudinous scutes of the little Teleost pipe-fish, appears somewhat hopeless; little less difficult, indeed, of satisfactory accomplishment than to identify the homologues of these great plates among the rhomboid or circular scales of a scaled Ganoid.

Leaving the anterior series of the ventral plates of *Coccosteus* and *Dinichthys* with the provisional interpretation given above, and passing to the posterior pair, we have still greater difficulty in following the lead of the great anatomists who have written on the affinities of the Placoderms.

It will be remembered that Mr. Parker says they may either belong to the post-clavicular cincture, or may represent the second pair of interclavicular bones of *Syngnathus*; while Huxley considers them the equivalents of the posterior pair of bones of the ventral shield of *Loricaria*,

^{*} Monograph on the Shoulder-Girdle, Plate 11, Fig. 1.

etc., and these as corresponding to the so-called "radius." Commenting on this interpretation, Mr. Parker says:

"Professor Huxley, in his invaluable 'Memoir on the Ganoids,' pp. 34, 35, speaks of the interclavicle as 'the so-called radius' (p. 35, Fig. 21, *d*), but it has nothing to do with Professor Owen's 'radius,' which is, in reality, the coracoid."

Here there is evidently a little confusion, for Mr. Parker elsewhere (Monograph, p. 29, near bottom) says: "The large bones below are best seen in Fig. 21, p. 35 (Huxley's Memoir), where *c* is the huge interclavicle;" whereas Prof. Huxley, on the page quoted above, compares the *antero*-lateral piece (interclavicle of Parker) with the "coracoid," and the *postero*-lateral piece with the so-called "radius." With this "coracoid" and "radius" matter we have, however, nothing to do further than to ascertain accurately Professor Huxley's view on the comparison of the ventral shields of *Coccosteus* and *Loricaria*, and to discover in what points Mr. Parker dissents from that view. The facts seem to be as follows: Professor Huxley compares the median plate of the shield of *Coccosteus* with the urohyal of *Loricaria*, the anterior paired plates of the shield of one with those of the other, and the posterior with the posterior. Mr. Parker, however, regards the anterior pair of the ventral plates of *Coccosteus* as the equivalents of the posterior pair of *Loricaria*, and both these as interclavicles; the anterior pair in the Siluroids being supposed by him to be clavicles.

To these conclusions I hesitate to subscribe, because if there is any homology between the ventral shields of *Coccosteus* and *Dinichthys*, and those of our living *Siluroids*—and this is rendered highly probable, both by the resemblances which they present and by the very evident homologies pointed out by Professor Huxley in the dorsal and cranial plates—the posterior pair of plates are, anatomically, the same in both groups.

This is indicated by their like position and backward reach, and by the peculiar processes which form the posterior lateral angles in each.

The position of these plates, as remarked by Professor Huxley, seems to be so far backward as to render it improbable that they had any connection with the pectoral fins, and I venture to suggest that they were post-umbilical and held the same position as the third pair of plates in the plastron of Chelonians; and further that they represent the palmated "interspinous" bones of *Caelacanthus*, and like them served as supports to the abdominal fins.

If this is true, they belong rather to the pelvic, than to the pectoral arches, and by their size, form, and solidity, were prophetic of the more complete condition of the pelvic arch which characterizes the higher classes of Vertebrates.

I have frequently been asked by those examining the bones of *Dinichthys*, what was the probable size of this great fish? and what inference as to its habits could be drawn from its remarkable dentition?

To these questions, which will doubtless suggest themselves to the readers of the foregoing pages, I will attempt such answers as are deducible from the facts in my possession. The size of the two species of *Dinichthys* was apparently about the same. This we infer from the relative size of the corresponding bones; the mandibles, for example, having a maximum length of about two feet in both.

The length of the body cannot be accurately determined from any facts yet obtained, as the caudal extremity was provided with no external or internal bony parts, which have been found. In all probability, it was, as in *Coccosteus*, protected by a leathery skin, and the vertebral column was cartilaginous.

We shall, however, find some traces of the interspinous bones, and the rays of the caudal fin, by which the length of the body may be ascertained, as has been done in regard to *Coccosteus*. If we take the proportions of *Coccosteus* (the nearest known ally of *Dinichthys*) as our guide, we may estimate the length to have been fifteen to eighteen feet, and the diameter of body about three.

In regard to the habits of *Dinichthys*, I think we may say with confidence that it was carnivorous. This is plainly taught by the dentition of *D. Hertzeri*, in which the mandibles and "maxillaries" are set with sharp teeth, which must have served to hold other fishes, perhaps the smaller ones, brought within the embrace of the formidable jaws. The cutting edges of the mandibles and "maxillaries" of *D. Terrelli*, are not so plainly indicative of a carnivorous habit, for some of the turtles are vegetable-feeders, with a dental apparatus similar in form and function too, though homologically different from that of this species of *Dinichthys*. Still, the huge anterior teeth, interlocking to a distance of three or four inches, would hardly have been used for any other purpose than for seizing and holding living, struggling prey.

As the dentition of *Lepidosiren* is almost precisely that of *Dinichthys*, it is doubtless used for the same purposes and in the same way. And since this similarity of dentition indicates a general similarity of habit, it has seemed to me that we might perhaps learn something of the nature of the food of *Dinichthys*, and his mode of seizing and masticating it, by observing the habits of *Lepidosiren*.

The fullest exposition of the anatomical structure of *Lepidosiren* will be found in Owen's Memoir, cited above, but this contains almost nothing in regard to its habits. The most satisfactory description of the life of the animal is furnished by the Rev. J. G. Wood, in his "Natural History." A

the information which he gives will doubtless be new to most readers, and throws some light on the manner in which the formidable dentition of *Dinichthys* was used, I venture to repeat here a portion of his interesting notes. After describing the appearance of *Lepidosiren*, he says: "The habits of this creature are very remarkable. Living in localities where the sun attains a heat so terrific, during a long period of the year, that the waters are dried, and even their muddy beds baked into a hard and stony flooring, these animals would be soon extirpated unless they had some means of securing themselves against this periodical infliction, and of obtaining, throughout the year, some proportion of that moisture for lack of which they would soon die.

"When the hot season has fairly commenced and the waters have begun to lessen in volume, the *Lepidosiren* wriggles its way deeply into the mud, its eyes being so constructed that the wet soil cannot injure them, and the external nostrils being merely two shallow blind sacs. After it has arrived at a suitable depth, it curls itself round, with its tail wrapped partly over the head. A large amount of a slimy substance is then secreted from the body, which has the effect of making the walls of its cell very smooth, and probably aids in binding the muddy particles together. When the rains fall, the moisture penetrates rapidly through the fissures of the earth, cracked in all directions by the constant heat, reaches the cell of the *Lepidosiren*, dissolves its walls, and restores the inhabitant to life and energy.

"Several *Lepidosirens*, or Mud-fishes, as they are popularly called, were sent to the Crystal Palace, while still in their muddy nests, or 'cocoons,' according to the technical term, and in one instance, three specimens were inclosed in a single lump of hard mud, weighing, when dry, about twenty pounds.

"On being immersed in water, the earthy cocoons fell to pieces, as if they had been made of sugar, and the imprisoned creatures were thus released. At first they were exceedingly sluggish, and hardly stirred, but after the lapse of an hour or two they became tolerably alert. * * * Finding that the *Lepidosiren* would rise to the surface of the water when a splash was made, the attendants used to feed it by paddling about with the finger, and then holding a piece of raw beef in the spot where the disturbance had been made. The creature used to rise deliberately, snatch the meat away, and, with a peculiarly graceful turn of the body, descend to its former resting-place for the purpose of eating its food.

"This mode of eating was very remarkable. Taking the extreme tip of the meat between its sharp and strongly-formed teeth, it would bite very severely, the whole of the head seeming to participate in the movement. It then seemed to suck the meat a very little farther into its mouth, and

gave another bite, proceeding in this fashion until it had subjected the entire morsel to the same treatment.

"It then suddenly shot out the meat, caught it as before by the tip, and repeated the same process. After a third such manoeuvre, it swallowed the morsel with a quick jerk. The animal always went through this curious series of operations, never swallowing the meat until after the third time of masticating.

"After a while, it was thought that the water in which it lived was not sufficiently warm to represent the tepid streams of its native land, and its tank was consequently sunk in the north basin of the building, where the water is kept at a tepid heat for the purpose of nourishing the tropical plants which grow in it.

"It remained here for some time, and being deprived of its ordinary supply of raw beef, took to foraging for itself. The gold-fish, with which the basin was stocked, became its victims, and it was quite as destructive as an otter would have been. It had a fancy for attacking the largest fishes; and though apparently slow in its movements, could catch any fish on which it had set its wishes. As the fish was quietly swimming about, suspecting no evil, the *Lepidosiren* would rise very quietly beneath it until quite close to its victim, just as the terrible ground-shark rises to take its prey. It then made a quick dart with open mouth, seized the luckless fish just by the pectoral fin, and with a single effort bit entirely through the skin, flesh, and bones, taking out a piece exactly the shape of its mouth, and then sinking to the bed of the basin with its plunder. The poor fish was never chased, but was suffered to float about in a half-dead state, and numbers of mutilated gold-fish were taken out of the basin.

"Not choosing to supply a succession of gold-fish, out of each of which the fastidious creature would only take one bite, the superintendent bethought himself of frogs, and fed the animal regularly with these batrachians. But having been warned, by the effect on the gold-fish, not to trust his fingers within reach of the teeth that could inflict such very effective bites, he got a long stick, cleft one end of it, put one hind foot of the frog into the cleft, and held it on the surface of the water, so that the struggles of the intended victim should agitate the surface.

"No sooner did the frog begin to splash than the *Lepidosiren* rose rapidly beneath it, seized it in its mouth, dragged it off the stick like a pike striking at a roach, and sunk to the bottom with its prey. Not a vestige of the frog was ever seen afterwards.

As has been remarked elsewhere, no traces of scales have been found with the remains of *Dinichthys*, and it is almost certain that it was not provided with scales; in this respect, as in many others, resembling *Coccosteus*.

The departure from this structure exhibited by the scaled body of the *Lepidosiren* will suggest itself at once as a marked point of difference between them, but we find great diversity in the dermal defenses of fishes even within the same family; for example, *Pterichthys* and *Cocosteus* seem to have been closely allied, yet the hinder portion of the body in one was scaled, in the other naked.

Again, in the living Siluroids most are without scales or plates, the body being protected, as in our cat-fishes, only by a leathery skin; yet, as we have seen, some genera of this family, as *Arius*, *Bagrus*, etc., have the region of the vital organs protected by large bony plates.

A similar difference seems to prevail between the ancient and modern representatives of the genus *Ceratodus*. No traces of scales have been found with the teeth of the Triassic species, while the living *Ceratodus* of Australia has the body covered with large scales, like those of *Lepidosiren*.

DINICHTHYS TERRELLI, Newb.

Charts V. and VI.

Dinichthys Hertzeri, N., in part, Vol. I., Part II., p. 316, Pl. 32, 33, 34.

Dinichthys Terrelli, N., Vol. I., Part II., p. 332, note.

As indicated in the above references, this species was named in a note appended to the description of *Dinichthys Hertzeri* in our first volume on Palæontology. On the preceding pages some of the bones belonging to this fish were referred to as parts of *D. Hertzeri*, and some of the figures given to illustrate the text were ascribed to that species; whereas, in fact, they represent bones of *D. Terrelli*. This confusion of the two species was occasioned by the circumstance that the most complete specimens found by Mr. Hertzer, at Delaware, consisted of the jaws and teeth, and for a long time almost nothing was known of the plates of the head and body of the Delaware species. Singularly enough, it happened that all the specimens found on the Lake Shore by Prof. Allen and Mr. Terrell during two years subsequent to the discovery of the first bone there, were cranial and body plates. Hence, the material for the diagnosis of the species was not in my possession, and all the bones from both localities were ascribed to *D. Hertzeri*.

The most characteristic features of *Dinichthys Terrelli* have been incidentally mentioned on the preceding pages; no extended description of the species is therefore required here. A concise review of its structure is, however, desirable for its more accurate definition, and to bring out the characters in which it differs from *D. Hertzeri*. Such a review is given below.

Cranium.—The form and dimensions of the cranium in *D. Terrelli* have not yet been fully made out, though several heads have been found, and one of these is figured, credited to *D. Hertzeri*, in Vol. I., Plate 33. This shows only the posterior half. The anterior portion seems to have consisted, originally, of several bones united by cartilage, for they are always found dismembered and displaced. This is also the case with the crania of the congeners of *Dinichthys*—*Asterolepis* and *Heterostius*—of the European Devonian. There was, however, a bony shell over the connecting cartilages, and, sooner or later, the head will, doubtless, be found so complete that its form and the homologies of its component plates can be fully made out. This I infer from the fact that a head of *Dinichthys Hertzeri* was found by Mr. Hertzer at Delaware, forming the nucleus of a large concretion, and retaining nearly the natural position of all its parts. The length of the head cannot be accurately determined, but it was, probably, about three feet. Its width, at the broadest part, was, perhaps, two feet. The largest cranium of *D. Terrelli*, found at Sheffield, measures thirty inches, from angle to angle, across the occiput.

The surface of the cranium was, as we know, gently arched, and, in its general aspect, smooth. The external surface everywhere shows a fine, almost microscopic figure, or grain, but nothing of the tuberculation common to all other known Placoderms. It is also marked, like *Coccosteus*, by a series of linear furrows which form a kind of Arabesque pattern. Whether the bones of the head of *D. Hertzeri* were similarly ornamented we have not yet learned, as the plates of the head, which has been referred to, and the only one found, are so much exfoliated that they show no markings.

The bones composing the cranium of *D. Terrelli* have rarely been found disarticulated. We are therefore unable to compare them in detail with those of *D. Hertzeri*, or those of other Ganoids. It is evident that in the living fish they were firmly soldered together, and formed a brain-case impenetrable to even the formidable dentition with which it was associated.

The occiput was symmetrically arched, the center, or keystone of the arch being formed by the Supra-occipital. This bone is triangular in outline, with a prominent point projecting from the middle of its longest and posterior side. In its central part it is sometimes three inches in thickness; below it is excavated on either side for articulation with the "*ossa articularia capitis*" (Epiotics?), and behind it slopes downward and shows a broad, deep, and partially double pit. In *D. Hertzeri*, the posterior margin of this bone is more nearly vertical, and bears at its central point a pyramidal projection, as does the corresponding bone in *Heterostius*; anterior to this and on the under surface of the thickest part,

is a single or double depression, also like that in *Heterostius*. This is the bone called by Pander *os occipitale medium*.

The lateral angles of the head are formed by what Pander calls *ossa articularia capitis*, shown in Figs. 3a, 3b, and 4, of Plate 34, Vol. I. The posterior angle of this bone is excavated to form a deep, somewhat conical socket, into which fits a strong condyle projecting from the middle of the Supra-scapula (Post Temporal), making one of the most complete joints known in the animal kingdom. It is strengthened by a guard, or rest, which projects like a flattened thumb, from the margin of the socket, backward, beneath the Supra-scapula. In all the specimens yet found the "*os articulare capitis*" is so firmly united to the other bones of the cranium that its outlines cannot be accurately determined. I have supposed that it represented chiefly the Epiotic, but it may also represent this bone inseparably blended with the squamosal and parietal bones. Future discoveries will probably afford the means for deciding this question.

Dentition.—The "premaxillaries" in *D. Terrelli* are triangular in outline, but are narrower than those of *D. Hertzeri*. They terminate below in a sharp but strong point. The upper margin, instead of being flattened and laminar, as in *D. Hertzeri*, is thickened, and the posterior lateral angle sometimes becomes a massive knob. The central position of the upper margin is excavated, forming a kind of socket. The exterior surface of the "premaxillaries" is smooth, and without the line of tubercles which ornament those of *D. Hertzeri*. The inner side is concave and frequently much worn and excavated by the prominent extremity of the mandible, over which it shuts. Front and lateral views of a complete "premaxillary" of medium size, are shown in Figs. 1 and 2, of Chart V.

The "maxillaries" are oblong with the angles somewhat rounded. The upper margin recedes, and near the anterior extremity bears a flattened process an inch or more in length. The external surface is slightly arched in both directions; it is nearly smooth, but along the lower margin, shows a band of low, flattened ridges (enamel folds). The interior face is concave, and on the lower margin, which is always sharp, it is more or less worn by contact with the knife-edge of the mandible upon which it plays. Figures representing the internal and external aspects of a "maxillary" of *D. Terrelli* are given in Chart V. (Figs. 3 and 4).

The "maxillaries" of *D. Hertzeri* are less quadrangular in form than in *D. Terrelli*, the lower margin being considerably the longer. They are also thinner and flatter, and are set with sharp, conical teeth.

The mandibles of the species under consideration have a maximum length of about two feet, the largest complete one in my possession being twenty-two inches in length. Two others which I have

are smaller, being respectively eighteen and twenty inches long, but both these are much worn, as though belonging to mature individuals. In all these the form is essentially the same, the anterior extremity is turned up, and terminates in a strong, acute, tooth-like projection. This is much worn, and was maintained in a sharp state by friction with the "premaxillary," into the concavity of which it enters. Behind this great tooth is a triangular, flattened projection, formed by a ridge on the inside of the mandible. Back of this, the upper margin of the mandible, for about six inches, is sharp, and is composed of dense, enamel-like tissue. At the posterior end of this sharp edge tubercles may frequently be discovered, which seem to be the rudimentary representatives of the teeth that surmount the margin of the mandible in *D. Hertzeri*.^{*} Usually the edge of the mandible is worn and sharp, from contact with the maxillary. The outline of this portion of the mandible is not all shown in Fig. 6 of Chart V., as both the triangular denticle and the cutting edge are broken away.

From the posterior end of the knife-edge of the mandible, a distinct shoulder runs in a curved line downward and forward to the beginning of the anterior curve. Above and before this shoulder the mandible is thick and massive, and was, evidently, never covered. The surface is nearly smooth, but shows everywhere the fine, granular reticulation which characterizes all the external surfaces of the bones of *Dinichthys*. The great terminal "tooth" is smooth, and wants the line of tubercles found on this part of the mandible of *D. Hertzeri*. The posterior portion of the mandible is flattened and smooth; in outline it is more spatulate than the corresponding portion of this bone in the other species, and is more turned up. All this part, as far forward as the shoulder referred to above, was, evidently, once covered with integument, or spliced on to the cartilage which formed the articular extremity. The more prominent characters mentioned in the above description will be seen in the full-sized figure of a mandible of *D. Terrelli*, represented on Chart V. (Fig. 6).

Body Plates.—The dorsal shield of *D. Terrelli* is so well shown in Fig. 5, Chart V., that no lengthy description is required of it. In the mature individual it is about two feet in length and breadth, one side being evenly rounded, the opposite one irregularly emarginate. Transversely, it is strongly arched; in its antero-posterior diameter, nearly straight. The external surface is smooth or granulated. Below, it bears along the central line an elevated, compressed ridge, which, at the curved margin of the shield, rises four inches from the inner surface, and has a

^{*} A precisely similar crenulation is visible on the corresponding portion of the lateral dental plates ("maxillaries") of *Lepidosiren*.

maximum thickness of about one inch. It projects beyond the curved border from six to eight inches in a flattened neck.

As has been before stated, the dorsal shield of *D. Hertzeri* is, as yet, imperfectly known. Two incomplete specimens, which I have, indicate that it was of nearly the same general size and form as that of *D. Terrelli*; but the neck-like projection is relatively much shorter, as though cut off, obliquely, from above.

The *Supra-scapulas* (or Post Temporals) of *Dinichthys Terrelli* are somewhat imperfectly represented in Figs. 1, 1a, 2, 2a, of Plate 34, Vol. I. They are flattened, triangular, or trapezoidal bones, about one foot in length by eight inches in width at the broadest part. They are thickest in the middle, where the exposed portion is comparatively small, and thin off on either side, where they are overlapped by other plates. Near the center of the thickest border a strong, flattened condyle is obliquely set, which fits into a deep cavity in the *os articulare capitis*.

The exposed portion of the *Supra-scapulas*, like the cranial surface, is marked by simple, linear furrows, which form some large pattern of ornamentation, as yet not fully made out.

The *Plastron* or ventral shield of *Dinichthys Hertzeri* is represented nearly complete, and of the natural size on Chart VI. The inside of the bones composing it is there shown. In the smaller diagram on the same chart, these bones are represented in position and seen from the outside. This shield is composed of five flat bones; two pairs and an elongated central one, which is interposed between them. The central plate is somewhat overlapped by the lateral ones, and when all are in their normal positions, the shield is twenty inches wide, and about three feet in length. The exposed surfaces of these bones are granulated, like those of the head, and the hinder pair are marked with the peculiar linear furrows seen on the bones of the cranium and the *Supra-scapulas*. The homologies of the bones of the ventral shield, and their correspondence with those of the ventral shield of *Coccosteus* have been discussed in the general description. The exterior margins of the anterior pair of plates (pre-ventro laterals, of Owen) show contact with other plates, and it is almost certain that the sides of the body between the dorsal shield and *Supra-scapulas*, and the ventral shield, were defended by plates of some kind, but none have yet been found that can certainly be referred to this position. Among the specimens collected at Delaware by Mr. Hertzer, and appertaining to *D. Hertzeri*, is one imperfect triangular plate, nearly three feet in length, and one foot wide at its broadest end. This, I have thought, might have occupied the side of the body, as there seemed no other place for it, but its location is yet only conjectural. No such plate has been found entire in connection with the remains of *D. Terrelli*, but a large number of frag-

ments of plates have been collected, some of which may have belonged to this region of the body.

Clavicles?—Reference has been made, on a preceding page, to the discovery by Mr. Jay Terrell of most of the bones of one large individual of *Dinichthys Terrelli*, lying together, but not in apposition. The more important of them are figured on Charts V. and VI., but with these are found several bones which have not yet been described. Two of them, forming a pair, are apparently Scapulo-coracoids (Clavicles, Parker). These are nearly two feet in length, and very massive. They are considerably curved in outline, about six inches broad in the widest part, toward the other extremity narrow and forked. The external surface is granulated like the bones of the head.

There are also two other plates of which the places are not yet determined. Of these, one is eighteen inches in length, seven inches wide in the middle, where it is broadest, and narrowing to the extremities, which are subacute. One of the sides is nearly straight, the other arched.

Only the central portion of this bone was exposed, as all the margins, except the straight one, are deeply impressed by the associated plates which broadly overlapped it. Whether this formed part of the defenses of the body, or protected the side of the head cannot yet be certainly told. Another plate found with this, is elliptical in outline, fifteen inches long (and incomplete at both ends) by ten inches wide. It is thin, flat, and without ornamentation. We may infer, from its symmetry, that it was placed on the median line. It is probable, also, that it was located on the under side of the body, but whether before or behind the ventral shield, remains to be determined.

With one of the heads of *D. Terrelli*, found at Sheffield, were two bones, forming a pair, which apparently correspond to those figured by Hugh Miller and Prof. Pander in their illustrations of *Asterolepis*, and called by the latter, *ossa anteriora lateralia capitis*. They are rudely triangular in outline, the broader side very thick. They were probably set on either side of the head near the muzzle, and formed the supports of the maxillaries.

GENUS COCCOSTEUS, Agass.

COCCOSTEUS OCCIDENTALIS (n. sp.).

Plate LIII., Figs. 2, 2 a.

Posterior dorsal plate somewhat urn-shaped in outline, four inches in length, one and a half inches in breadth, broadly emarginate above and terminating posteriorly in a long, acute, smooth, styliform point. The

anterior half of the upper surface is mostly smooth. The posterior half and margins of the anterior portion are set with relatively fine crowded tubercles.

The specimen now described gives us the first intimation of the existence of the remains of *Coccosteus* on the North American continent. This was obtained by Mr. J. H. Klippart from the Corniferous limestone at Delaware, Ohio. It is plainly the post-dorsal shield of a Placoderm, and corresponds so closely in size, form, and markings with the terminal shield of the carapace worn by some species of *Coccosteus* that I have little hesitation in referring it to that genus. The resemblance to which I refer will be seen by comparing the figure of the fossil now described with that of the dorsal plate of *Coccosteus cuspidatus*, Agass., on the same plate and drawn from a specimen recently received from Scotland. A single rhomboidal plate shown on Plate LIV., Fig. 2*a*, may be the central plate of the ventral shield, but unfortunately only its inner surface is shown, and from this we should be unwarranted in pronouncing it a plate of *Coccosteus*. There is good reason, however, for believing this to be the case. It certainly does not belong to the bony structure of any of the more common fishes of the Corniferous limestone, and its symmetrical form indicates that it held a central position in the ventral shield of some Placoderm allied to *Pterichthys* and *Coccosteus*.

For comparison with this, representations of the external and internal surfaces of the ventro-median plate of *Coccosteus* are given in Figs. 4, 4*a* of Plate LIV.

The discovery of the remains of *Coccosteus* in the Devonian rocks of America is a fact of interest as adding another to the forms of ancient life common to the old and new worlds; but it has been long expected, and, since this is one of the most characteristic fossil fishes of the Old Red Sandstone of Scotland, and has been met with in Russia and Bohemia, its absence from all collections of fish remains heretofore made in this country has been a matter of some surprise. I have offered an explanation of this absence, however, in the Palæontology of our first volume, by suggesting that the fish remains found in the Old Red Sandstone of Scotland were taken from a different member of the Devonian system, and from deposits of a different character from that—the Corniferous limestone—which has furnished most of our Devonian fishes. The Corniferous limestone is the central member of the system, and is an open sea deposit, while much of the Old Red Sandstone is of later date, and is a shore deposit, formed either in fresh water, as supposed by Prof. Ramsay, or in bays or gulfs. I have suggested, therefore, that the remains of *Coccosteus*, *Pterichthys*, and the scaled Ganoids, *Osteolepis*, *Dipterus*, etc., as well as the Acanthodeans, so common in Europe, and heretofore not found in this country, would probably be discovered in the Catskill and

Chemung rocks, where they should be carefully searched for. This prediction has been verified, as far as regards *Dipterus*, by the recent discovery, by Mr. Andrew Sherwood, of a species of this genus in the Catskill of Pennsylvania.

The finding of *Coccosteus* in the Corniferous limestone of Ohio is a fact which will be regarded as discordant with the view that this was a fresh water, or shore-inhabiting fish; but the discordance is more apparent than real, for the specimen now figured is unique in all the great collections of fish remains made from the Corniferous limestone during the last twenty-five years.

This indicates the rarity of this fish in the *sea* of the Devonian age, and the presence of its bones, in this one instance, in the sediment of that sea, must be looked upon as an exceptional fact, like the finding of the floated trunks of tree ferns in the same formation and locality. The open sea was evidently not the *home* of *Coccosteus*, either in America or in Europe. The discovery of its remains here proves that it had a home in the Western Hemisphere, but we have not yet found it; and the probability is strengthened, that if sought in the shore and off-shore deposits of the Chemung, Catskill, and Vespertine of Pennsylvania and New York, the remains of *Coccosteus* will be met with in greater abundance than anywhere in the Corniferous limestone. We may also look there for the associates of *Coccosteus* in the old world—*Pterichthys*, *Cephalaspis*, *Acanthodes*, etc.,—as the unity of the Devonian fauna is such that we may expect to find in America representatives of all the more common genera of the European Devonian rocks.

In his interesting paper on *Ceratodus Forsteri*, Dr. Gunther proposes to group the Ganoids and Elasmobranchs together in one sub-class, to which he gives the name of *Palæichthyes*; thereby indicating their antiquity. He also makes the generalization that the Elasmobranchs were the marine, and the Ganoids the fresh-water fishes of ancient times. With this latter view, I cannot coincide, as I have elsewhere shown that in the Devonian age the Ganoids far surpassed the Elasmobranchs in number and size, and that they were the rulers of the seas as well as of the rivers and lakes. This is proved by the abundance of the remains of the great Ganoids, *Onychodus*, *Macropetalichthys*, etc., in the Corniferous limestone, which is unquestionably a marine formation; and by the few and small relics of Elasmobranchs associated with them. Among the many thousands of fish remains from the Corniferous limestone, which I have examined, I have seen very few that could be referred to the group of Elasmobranchs. In the Carboniferous sea a different state of things prevailed.

There the Elasmobranchs were numerous and powerful; while in this age the Ganoids were almost exclusively confined to the shores and inland waters.

CHONDROSTEIDÆ (?).GENUS *ASTEROSTEUS* (nov. gen.).

Of this fish the cranium only is known, and of this all the specimens yet obtained are incomplete. The head was apparently long and narrow, the sides nearly straight, broadening suddenly in the occipital region. The posterior margin of the cranium shows two broad arches—one on either side of the median line—in which the cranial bones are deeply excavated, as though for muscular attachment. The skull is terminated behind by two conspicuous rounded projections having the aspect of condyles, but which, so far as can be seen, show no articulating faces. The upper surface of the cranium is covered with relatively large, beautifully stellate tubercles, which vary considerably in size. Toward the nasal extremity are two linear furrows which diverge from the middle line of the cranium, and inclose two strongly-marked elliptical pits that closely resemble the nostrils of some reptiles. In none of the specimens of this peculiar fish yet obtained, have the outlines of the cranial plates been distinguishable; the surface being covered by a sheet of tuberculated enamel by which the sutures are entirely concealed. On the sides, the cranium is somewhat beveled off, as though for the attachment of some coriaceous or ligamentous appendage, or perhaps for co-adaptation to lateral head plates; none of which have, however, been found. The dentition of *Asterosteus* is quite unknown, as no jaws or teeth have been discovered with its remains.

The figure given on Plate LIV. will show better than a description the general aspect of this singular cranium, and there are certain features which it reveals, that will strike the most casual observer. These are the condyle-like posterior projections of the skull, and the strongly marked nasal pits. Until more material shall be accumulated for determining its structure and relations, it would be presumptuous to make any comparisons between this fish and other known living or fossil forms, but the reptilian aspect of the cranium will not fail to be noticed by all who shall see the figure now published. So far as yet known no reptiles existed in the Devonian age, and the reptilian features presented by *Asterosteus* are perhaps merely superficial resemblances, but there is little doubt that if found in rocks of a later date, this would be considered (until proof to the contrary were gathered) the cranium of a reptile or amphibian. Though a number of crania of *Asterosteus* have been obtained in the Corniferous limestone of Ohio, none of them show either jaws or teeth, and it is quite

possible, therefore, that we have in this fish an ally of *Macropetalichthys*, and thus, perhaps, a Chondrosteian in which, as in the sturgeon, the sides and lower portions of the head were protected simply by a leathery integument. Future discoveries will doubtless make more plain what is now so obscure in the structure of this fish.

ASTEROSTEUS STENOCEPHALUS (n. sp.).

Plate LIV., Fig. 1.

Head 8 inches or more in length, by $2\frac{1}{2}$ inches in width, except at the occiput, where it suddenly widens and becomes 4 or 5 inches broad. It terminates posteriorly in two excavated arches, of which the surface is roughened, apparently for muscular attachment. Projecting behind and below these arches are two bony condyloid prominences an inch or more in length. The upper surface of the cranium is somewhat irregularly covered with stellate tubercles which vary in size from one-eighth to one-twentieth of an inch in diameter. The sides of the cranium are somewhat beveled and roughened, and are traversed by an irregular line of relatively large tubercles. Near the anterior end the head seems to be suddenly narrowed, and just at this point it bears two deeply impressed, elliptical, nasal (?) orifices, placed side by side, somewhat divergent forward, and having a length of 5 lines and a breadth of 2 lines. The dentition is entirely unknown, as also the covering of the body.

Formation and locality: Corniferous limestone, Sandusky and Delaware, Ohio.

CEPHALASPIDÆ (?)

GENUS ACANTHASPIS (nov. gen.).

This name is used to designate certain cranial bones of what seems to have been a Cephalaspid, found in the Corniferous limestone of Ohio. Considerable variety is noticeable in the shape of these plates, and it is apparent that they formed parts of a tessellated cranium. They are generally somewhat oblong in form, the greater part of the plate being quadrangular, while one of the margins is oblique and prolonged into an acute point, and to this margin is spliced a carinated, toothed spine, sometimes four or five inches in length. These spines bear considerable resemblance to the dorsal spines of some extinct sharks. They might, indeed, under some circumstances, be accepted as the spines of *Ctenacanthus*,

since they are marked with pectinated ribs much in the same way, but their attachment to bony plates and the denticulation of *both* sides of the pointed extremity shows distinctly that they have only a superficial resemblance to the defensive spines of Elasmobranch fishes. When complete and seen in position they reveal their affinities with the lateral cornua of the cephalic buckler of *Cephalaspis*. The external surface of the plates to which these spines are attached is marked with a conspicuous and peculiar ornamentation, much like that of *Bothriolepis*, a series of convoluted, locally parallel, raised and beaded lines. As the cranial plates of *Acanthaspis* have never been found in connection, it is impossible to give at present the form of the cranium, but they are seen to be in pairs, and it is highly probable that when united they formed a rounded head-buckler which differed from that of *Cephalaspis* mainly in being composed of a series of separable plates, instead of forming a solid box.

ACANTHASPIS ARMATUS (n. sp.).

Plate LV., Figs. 1-6.

Cranium consisting of a number of bony plates, forming several pairs, and differing considerably in outline. To at least one of these pairs are attached, on the outer margin, strong, slightly curved, carinated, tuberculated and toothed spines. The external surface of the plates is covered with convoluted or radiated raised lines, which are more or less tuberculated.

Several cranial plates of this species are represented in the figures now published, and these will give a better idea of their form and marking than any verbal description can do. These plates, and the spines which are connected with some of them, are frequently met with in the Corniferous limestone of Sandusky and Delaware, but, like the cranial plates of *Onychodus*, they seem to have had no bony attachment to each other, and, in the dissolution of the body of the fish which bore them, they have been widely separated. There is little doubt that, sooner or later, some cranium will be found in which the bones hold their normal positions, and, from such a specimen, a more complete description of the fish can be drawn than can now be given. Waiting the discovery of such complete material, the plates now figured will, doubtless, be looked upon with interest, and will stimulate the search for more remains of what has hitherto been an entirely unknown Devonian fish.

Figures 1 and 2 of Plate LV. represent a pair of plates which occupied corresponding positions on opposite sides of the head (?) of, perhaps, the

same individual. In these plates the external markings are nearly obliterated, slight traces, only, of the tuberculation remaining.

Fig. 3 shows a similar plate, in which the surface-markings are somewhat more distinct, and the suture between the plate and the attached spine is plainly visible.

Fig. 4 gives an inside view of a plate which, like the preceding ones, carries a spine, but its form is quite different. A number of such plates have been found with those having the shape of Figures 1, 2, and 3, so that I have supposed them all to belong to the same species. The spines attached to the smaller plates were, apparently, without denticles.

The plate represented by Fig. 5 has a different outline from either of those before mentioned, but they are often found together, and the tuberculation, though stronger in Fig. 5, is essentially the same as in Fig. 3. Fig 5 *a* represents a portion of the surface of Fig. 5, slightly magnified.

Fig. 6 shows the inner face of a plate like Fig. 3, without its spine.

Formation and Locality: Corniferous limestone, Sandusky and Delaware, Ohio.

GENUS ACANTHOLEPIS (nov. gen.).

Among the many fish remains found in the Corniferous limestone, there are none more puzzling than those to which the above name has been given. They consist of tuberculated cranial or dermal plates, which have a prevailing spatulate outline, but which differ very much among themselves in form and consistence. Some are thin and have somewhat the appearance of large, elongated, unsymmetrical scales. Others are stronger, and are produced into points that sometimes become spines. The surface of all these plates is more or less tuberculated; the tubercles in some of them being strong and closely crowded, in others sparse and fine. Whether these are body scutes or cranial plates remains to be shown by farther discoveries. That they form parts of a somewhat extended series is shown by the fact, that, in some instances, two or more are found occupying nearly their true position as regards each other.

ACANTHOLEPIS PUSTULOSUS (n. sp.).

Plate LVI., Figs. 1-6.

Cranial or body scutes, having a somewhat spatulate form, and attaining, in some cases, a length of seven or eight inches, with a width of two inches. These scutes were set contiguous to each other to form a defense

to the body or head; the more elongated ones becoming real curved spines, similar in general character to those of *Acanthaspis*, but differing in this, that they are not united by sutures with flat bones or plates, but are the extremities of such plates drawn out into spines that must have projected from the general surface. The broader plates are quite thin and seem to have been applied to flat or arched surfaces, while those which form spines have their remote extremities narrowed and thickened till they become prominent and effective defensive organs. In some instances the plates are triangular in outline and seem to have been thin cones of bone or enamel, supported by cartilaginous centres. As the latter are decomposed, the sides, which were once widely separated, are brought together, or crushed in like broken shells.

The external surface of these plates is tuberculated in a variety of ways. In some instances the tubercles are large, scattered, smooth and round, and resemble pustules. In other cases they are irregular and crowded; while occasionally they are in regular rows; the interstices between them being beautifully chased and ornamented. Along the margins of the spinous extremities of the plates, the tubercles are elongated until they become conical denticles. In a paper published by the writer some years since in the "Bulletin of the National Institute" at Washington, descriptions were given of a number of fish remains obtained at Delaware, Ohio, by the late Dr. Mann. Among these, three species of "*Oracanthus*" were described, viz.: *O. fragilis*, *O. granulatus* and *O. abbreviatus*; all of which I now believe to be simply phases of the varied scutes of *Acantholepis*. Some of the triangular ones seem to have resembled, in form and function, the dermal spines of *Climacium*, *Paraceras*, etc., and it is quite possible that they were set in greater or less number on the body. In the reduced outlines, shown in Fig. 1 *b*, the relative positions of two pairs of the larger scutes were given, and we may infer from these that they were set along certain lines, more likely on the body than head (since, except laterally, they show no signs of contact), just as the dermal scutes are placed in *Accipenser*.

Much more material will be required before we can reconstruct *Acantholepis*, but its remarkable scutes are so frequently met with in the Corniferous limestone, that it is evident it was numerously represented in the Devonian sea. Future discoveries will, unquestionably, give us the full information about it which we crave, but which is as yet beyond our reach.

On Plate LVI., Figs. 1, 1 *a*, represent a large pair of plates in their relative positions. A number of pairs of this kind have been found, though the individual plates are oftener met with entirely separated from their connections. The extremity of Fig. 1 is not quite complete. Other speci-

mens show that it was produced to a moderately acute, flattened point. This narrow end was beautifully denticulated, was tuberculated on both sides, and evidently projected from the body or head as a defensive spine.

Fig. 2. represents the inside of a scale-like scute, which was probably attached by its entire under surface. At the narrow end the bone is removed, revealing the impressions of the tuberculation of the outer surface.

The original of Fig. 3 is a small scute corresponding to 1 *a*; though drawn out to an acute point it was not a spine.

Figs. 4, 5, 6 represent broader and narrower spine-like scutes, which I have reason to believe belonged to the same species with the scutes from which Figs. 1, 2, and 3 are drawn. Specimens of intermediate character seem to unite them all together.

Formation and locality: Corniferous limestone, Sandusky, Kelly Island, Marble Head and Delaware, Ohio.

FISHES OF THE CARBONIFEROUS SYSTEM.

MARSIPOBRANCHII (?)

“*CONODONTS*.”

Plate LVII.

In the first volume of this Report reference was made in several places to certain minute, comb-like or tooth-like organs, found in great numbers in the Cleveland shale of the Waverly group at Bedford, Cuyahoga county. They are from one-twentieth to one-fourth of an inch in length, and usually consist of a narrow, compressed, slightly arched base, from which spring numerous flattened denticles. These are generally long lance-shaped, and very acute at the margins and summits (see Figs. 1, 2, 12, 14, 16, 18, 19, 20).

Occasionally they are in part rounded and obtuse (Figs. 3, 9, 10, 15), but much oftener are acute and somewhat subulate. A not uncommon form is represented by Figs. 4 and 8. In this variety the base is elongated and narrow, in a few cases rod-like, and but slightly curved. From this base rises a series of denticles of nearly uniform size, connected by coalescing intermediate ones of two-thirds their height; the whole forming a fin-like margin or wing. Still another variety is seen in Fig. 1. In this the teeth are fine and closely approximated, and the organ has a wonderful likeness to an elongated comb.

The material of which the Conodonts are composed is slightly translucent, horn-like in color, and closely resembles the enamel of many teeth.

The number of these objects is immense, and the variety of form which they exhibit, is but imperfectly shown in the figures now given. In regard to their zoological relations it is as yet quite impossible to speak with certainty. The Conodonts found by Prof. Pander in the Lower Silurian marls of St. Petersburg, Russia, were considered by him to be the teeth of small sharks. This conclusion has not been generally accepted by other palæontologists, though no perfectly satisfactory explanation of their zoological relations has been offered. Prof. Owen (Palæontology, p. 116), discusses their structure and affinities at considerable length, and concludes that “they have most analogy with the spines, hooklets, or denticles of naked mollusks, or annelids.”

When Conodonts were first found in Ohio, I submitted them to Prof. Agassiz, who pronounced them the teeth of Selachians.

Prof. E. S. Morse, one of the best living authorities on the structure of invertebrate animals, to whom they were referred as possibly the teeth of naked mollusks, such as *Doris*, *Æolis*, etc., said that they bore a strong resemblance to the teeth of mollusks, and might have belonged to the progenitors of some of our living forms.

The late Prof. Wm. Stimpson, one of our most learned and accurate zoologists, and one who had given special attention to the *Crustacea*, after examining a large number of Conodonts, gave the opinion that they might very well be the lingual teeth of mollusks, but they could not have formed the dentition or spinous armanent of any Crustacean.

The Conodonts found by Prof. Pander were submitted by him to chemical analysis, and he found them to be composed of carbonate of lime. English chemists have found in them traces of phosphate of lime.

Under the microscope they are shown to be composed throughout of concentric layers of fine, structureless, but punctate tissue, not exactly like that of the teeth of any living fishes; though their peculiarities of structure are not such as necessarily to exclude them from that class.

It has also been suggested by some zoologists that these singular bodies are the teeth of Cyclostomous fishes, and by others that they are dermal ossicles. These different theories will be briefly noticed in order.

1. That the Conodonts were not the teeth of Selachians seems to me almost certain, from their small size, their peculiar forms, and the homogeneity of their composition. In all known sharks the teeth are composed of two distinct portions, the crown and the base. Of these the first is the only part exposed, and it is formed of very dense tissue (dentine), traversed by radiating and ramifying canals, and is covered with enamel. In the center is a pulp cavity, or less dense cancellated tissue.

The base is usually composed of rough, more or less porous, bone. This is sunk in the integument and adheres to the cartilaginous jaw by strong ligamentous attachment. The line of demarcation between the crown and base is generally well marked, and when the teeth are fossilized, the soft base has often perished, while the hard crown remains unchanged. In the Conodonts, on the contrary, the crown and base are similar in composition, or, rather, they have no base such as sharks' teeth exhibit. From the form of their inferior margins we may infer that they were implanted in soft tissue, like the teeth of mollusks, the hooks of annelids, etc., and were not set on jaws.

2. Excluding the theory that they were the teeth of sharks, the range of possibility in their affinities is still great. They may, as suggested

by Owen and Morse, be the teeth of mollusks, for they strongly resemble them in their peculiar and varied forms and their chitinous composition, but if the teeth of mollusks, these must have been shellless, for no molluscous shells have been found in the formation which contains them, and it would be somewhat singular if the *Mollusca* were represented in the sea from which the Huron shale was deposited, only by naked species.

3. In the first volume of this Report I ventured to suggest that the Conodonts might be the dermal ossicles of ancient fishes. Among the Elasinobranchs there are some of which the external surface is protected by a shagreen composed of divergent, acute ossicles, not very unlike some of the Conodonts in form and composition. We know of no shagreen, however, composed of such neat, regular bodies as the Conodonts are, and the conjecture that they may be the shagreen of sharks is as yet supported by little evidence.

I also called attention to the fact that the scutes of the Sturgeon, about and within the branchial apertures, have almost exactly the outline of the simpler Conodonts, but further observation has led me to consider this resemblance as accidental, and without zoological significance.

4. Waiting further evidence of the nature of these interesting organs, I take the liberty of offering, as a possible and plausible explanation of the enigma, the theory that they are the teeth of Cyclostomous fishes. If any one will take the trouble to compare the Conodonts with the teeth of *Myxine* and *Bdellostoma*, he will find a very close and remarkable similarity between them. Indeed, except that they are very much larger, the teeth of *Bdellostoma polytrema* are almost exactly like the Conodonts represented in Figs. 12, 14, and 16. The teeth of *Myxine glutinosa* are even more like these in size and delicacy of structure, and scarcely less so in form, than those of *Bdellostoma*. In composition and internal structure, the teeth of the modern Marsipobranchs seems to be almost identical with the Conodonts, and the resemblances which they present are throughout so strong that few will make a comparison between them without being convinced that they are nearly related zoologically. From the low place held by the *Marsipobranchii* in the zoological scale we might naturally suppose that they existed in considerable numbers in the Palæozoic seas, and it has been a matter of some surprise that no traces of them have been heretofore recognized in any ancient strata. This fact has been explained by the suggestion that none of the Cyclostomes have organs composed of tissues that would resist decay.

This explanation is, however, not altogether satisfactory. It is true that nothing but the teeth would be likely to be preserved, but even if composed of horn-like tissue, as in *Petromyzon*, they should have left some traces when buried in the finer sediments; when harder, like those of

the Myxinoids, they would certainly be preserved. Possibly some other relics of Cyclostomous fishes will yet be found, but with the facts now before us we seem justified in concluding that if the Conodonts are not the remains of Marsipobranchs, these vertebrate animals, though very low in the scale of beings, are, like Fungi, Lichens and Mosses among plants, of modern date. If, however, the view now proposed be proven true, in the Conodonts of the St. Petersburg Silurian marls, described by Pander, those of the Mountain limestone of England, collected in such numbers by Moore, and in those of the Waverly of Ohio, we have a very respectable representation of this group of fishes in the Palæozoic faunas; for they exhibit so great a variety of form that if they are the teeth of fishes they are the relics of many genera and species. This hypothesis encounters a difficulty in the fact that while the Conodonts are calcareous, the teeth of the living Cyclostomous fishes are horny or chitinous. It is quite possible, however, that the ancient species had calcareous teeth, and in that respect differed from the modern ones; just as the calcareous sponges, so common in the Palæozoic seas, have, for the most part, been superseded by those having horny tissues containing siliceous spicules.

A similar objection may be urged against the theory that the Conodonts are the teeth of Mollusks, as the modern *Mollusca* have siliceous teeth.

More proof must be gathered before it can be positively asserted that the Conodonts are teeth of Marsipobranchs, but they resemble them so closely that it seems at least possible that we have in these delicate organs the teeth of small Lampreys, or Hags, which inhabited the Palæozoic seas in large numbers. If this is their true nature, they represent the first fishes that existed on the globe; unless, indeed, they were preceded by the progenitors of *Amphioxus*, and they, like the living Lancelet, were without hard parts, and could leave no trace of their existence.

ELASMOBRANCHII.

GENUS DIPLODUS, Agass.

In the notes on *Diplodus* published in the first volume of this Report (Part I., p. 334), three species found in Ohio are described, but no figures of them are given. These are all now figured on Plate LVIII. Figs. 1, 1 a, 1 b, represent *Diplodus latus*; fine specimens of which have been obtained from Linton during the past year. As will be seen from the figures, this species may be readily recognized by its large size, its broad,

lance-shaped and serrated cornua, by its tuberculated base and by the absence of a median denticle.

Diplodus compressus (Fig. 2) is never more than half as large as *D. latus*, and has relatively broad, serrated, flattened and divergent cornua. These are often nearly straight, and sometimes have the sharpness of the edges increased by a concavity of the slope from the median line. It might be supposed that this was only the immature state of *D. latus*, which it somewhat resembles in form, but in that species the cornua are more lance-shaped and the surfaces more uniformly arched. The tuberculated base and the absence of a median denticle are also characters wanting in *D. compressus*. It may be said also that some thousands of the teeth of the latter species have been found at Linton, so like in size and shape that they evidently exhibit its normal features. From this average character the teeth of *D. latus* depart very widely.

As has been elsewhere remarked the differences between *D. compressus* and *D. gracilis* (Figs. 3, 3 a) are not strongly marked nor very constant, and they may be but varieties of the same species. The figures now published will show that the teeth named *D. gracilis* are narrower, with less spreading, more curved, and less flattened cornua, than those to which the name *D. compressus* has been given. There are, however, among the specimens from Linton, some teeth which seem to share the characters of the two species, and it may be found that they run into each other. Several jaws have been obtained at Linton to which the teeth of *Diplodus* are still attached. These have been carefully examined in order to ascertain what diversity of form could be observed in the dental series of one individual, but they are too imperfect to fully settle this question. The upper and lower jaws have not yet been found together, and although there seems to be less variation of size and form than was expected in the teeth of a single jaw, the teeth of the upper and lower jaws may have been somewhat different. It will be necessary to have the entire dentition under view before the limits of variation in the teeth can be accurately defined.

CLADODUS ACUMINATUS, Newb.

Plate LVIII., Fig. 4.

Cladodus acuminatus N.; Proc. Phila. Acad. Nat. Sciences, 1856, p 99.

Teeth of medium size, average specimens being about one inch in height, and three-fourths of an inch in breadth of base; central denticle robust, conical and very acute, with a nearly circular section throughout, both

anterior and posterior faces strongly striated. Lateral denticles four, the outer pair largest, all conical, acute and striated. Base elliptical in outline, thin and sharp-edged.

The most distinctive character of this species is the extreme sharpness of the strong central and lateral denticles. They all have a nearly circular section, and are distinctly striated; at their summits they are drawn out into fine points more elongated and acute than in any other equally large species with which I am acquainted.

Formation and Locality: Bituminous shale over Coal No. 5, Mineral Point, Tuscarawas Co., Ohio.

CLADODUS HERTZERI (n. sp.).

Plate LVIII., Figs. 5, 5 a.

Teeth broader than high, massive and strong; base semi-elliptical in outline, 7 lines long by $3\frac{1}{2}$ lines wide; central cone 6 lines high, robust, conical, subacute, with a circular section, considerably inclined backward; lateral denticles, two pairs, the interior pair more than half as large as the central cone, outer pair much smaller; both central and lateral cones rather finely striated, striæ strongest on posterior face and sides.

The most striking peculiarities of this remarkable species, are the breadth of the base, which exceeds the height of the central cone, and the reversed and abnormal inequality in the size of the lateral denticles. In most species of *Cladodus*, the external pair are longer than the intermediate ones, and Agassiz, in his description of the genus (*Poissons Fossiles*, Tome III., p. 196) makes this a diagnostic character, and that by which he distinguishes *Cladodus* from *Hybodus*. There is little doubt, however, that *Cladodus* of the Devonian and Carboniferous, is represented by *Hybodus* in the Mesozoic rocks. The two genera slide into each other in such a way that it is impossible to draw any sharply-defined line between them, and it is difficult to resist the conclusion that the relationship which they hold to each other is a genetic one; in other words, that *Hybodus* is descended from *Cladodus*.*

The rule given by Agassiz for distinguishing these genera is, however, of such general application, that it seems hardly necessary to modify it, further than to report some exceptions to it.

*Mr. W. J. Barkas, in a paper published in the Geological Magazine of April, 1874, claims to have discovered true *Hybodus* in the Coal Measures of Northumberland and Staffordshire, England.

Among all the species of *Cladodus* known to me, there is only one other than that now described, in which the exterior pair of lateral cusps are larger than the inner ones. This is a beautiful new species sent me by Dr. C. Rominger, the State Geologist of Michigan, and by him obtained from the Waverly group of that State. A brief description of that species is appended, but the specimen came to me too late to be figured for this volume. In *C. Romingeri* the interior pair of secondary cones is very little larger than the outer ones, while in *C. Hertzeri* they are more than twice as long.

Formation and Locality: Obtained by Rev. H. Hertzer from the beds of impure limestone in the red shale, under the Berea Grit at Berea, Ohio.

CLADODUS PATTERSONI (n. sp.).

Plate LVIII., Figs. 6, 6 a.

Teeth small, not exceeding 6 lines in height; base small, rounded, bearing no lateral denticles. Median cone robust, much reflexed and sigmoidally curved at point, smooth and polished throughout. Near the base the section is circular, toward the apex flattened with a winged margin that makes it strongly ancipital. The small, rounded base apparently supported only one cone. The plain and polished surface, strong curvature and ancipital apex of the central cone, will serve to distinguish this species at once from any other.

A specimen collected by Prof. Andrews is of special interest, as it consists of a lower jaw bearing nearly its entire dentition, the teeth in position. These are placed apparently in quincunx order, alternating instead of forming antero-posterior rows as in most of our sharks. So far as can be seen all the teeth have precisely the same form; those situated at the lateral extremities of the dental area being much smaller than the others, but not otherwise different. The number of teeth borne by both jaws must have been three hundred to four hundred.

Formation and Locality: "Waverly Black Shale," Waverly, Ohio.

CLADODUS SUBULATUS (n. sp.).

Plate LVIII., Fig. 7.

Teeth small, 6 lines in height and breadth; base elliptical, equal in breadth to height of tooth, bearing a central cone with two nearly equal

lateral denticles on either side, all striated. Central cone slightly recurved, section above nearly circular, below, posterior face flattened, giving lateral angles.

This species is about equal in size to *Cladodus Pattersoni*, but may be readily distinguished from that by its lateral denticles, less curvature and striated surfaces.

Formation and Locality. Cuyahoga Shale over Berea Grit, Berea, Ohio.

CLADODUS CONCINNUS (n. sp.).

Plate LVIII., Fig. 8.

Teeth small, about 6 lines in height and breadth; base very narrow, boat-shaped, with pointed extremities; central cone much compressed with sharp edges, posterior face flat, anterior rounded, both strongly striated; lateral denticles two pairs, both striated, external pair the larger, and divergent.

This small species is noticeable for its compressed, double-edged, and strongly-striated cone, its divergent lateral denticles, and narrow pointed base. These characters will serve to distinguish it from any others with which it may be compared. It is not unlike in general appearance *C. zygopus*, described in the Illinois Geological Report, Vol. II., p. 25, Plate I., Figs. 9, 9 a, 10, but in that species the base is distinctly yoke-shaped—i. e., arched on one side, excavated on the other—and the posterior face of the cone has a deep furrow at the base.

This is the most elegant in form and most highly ornamented of all the species of *Cladodus* yet found in Ohio, and the specific name given it was chosen to indicate this.

Formation and Locality: Huron Shale; valley of Black River, Lorain County.

CLADODUS PARVULUS (n. sp.).

Plate LVIII., Figs. 9, 9 a.

Teeth very small, and exhibiting two forms; the larger 4 lines high and broad; crown compressed and ancipital; summit very tapering and acute; anterior face rounded; posterior flattened, often slightly keeled above, deeply excavated below; both faces toward the base having fine, somewhat interrupted and irregular striæ; lateral denticles two, flattened, triangular, divergent; base yoke-shaped, posterior margin deeply sinused, under surface concave.

Smaller form without lateral denticles, from 2 to 3 lines high, central cone and base as in larger form. These small teeth occur in large numbers in the fish bed discovered by Mr. Jay Terrell in the valley of Black River. As will be seen from the description given above, they differ much among themselves in form and size, but between the extremes are all possible shades of variation. The peculiar yoke-shaped and cupped base is the same in all, but some have no lateral denticles, others have tubercles at the sides of the central cone, while others still have two well-developed lateral cones. This diversity is not greater than we find in the dentition of modern sharks, and it is highly probable that in all of the species of *Cladodus*, the teeth were more or less variable in size and form according to the places they held in the mouth. This introduces an element of uncertainty in the diagnosis of species from a few teeth, which should be kept in mind in describing or discussing species of this and other genera of extinct sharks. It is not probable, however, that the species of *Cladodus* have been very much multiplied from this cause, for the reasons that: (1) the number of species yet described is small, (2) they are distributed through a great vertical and geographical range—from the base of the Devonian to the Permian, and from Russia to Kansas—very few having been taken from the same stratum and locality, and (3) the dentition of each species, however much varied, has generally something in common, of form or ornamentation, by which the different members of the series may, with due care, be identified.

The danger of multiplying species from this cause is at least not sufficient to make it necessary or wise to neglect all material of this kind until such time as the complete dentition of each species shall be discovered. This cannot be hoped for in regard to many fossil sharks, as their skeletons were cartilaginous, and the connection between the teeth and jaws was ligamentous and was dissolved in decay. In the only cases that have come under my observation where any considerable portion of the dental series has been found with the teeth in position (*Cladodus Pattersoni* and *Diplodus compressus*), the only difference visible among some hundreds of teeth shown is in size. Had the entire dentition of both jaws been visible in these cases, their testimony would have been more conclusive, but it has much weight as it is.

CLADODUS ROMINGERI (n. sp.).

Teeth small, breadth of base 7 lines, height of median cone 5 lines; central cone flattened behind, anterior face rounded; basal portion of posterior face deeply sinused; lateral cones two pairs (sometimes with a

rudimentary one at the base of the central cone), of which the inner pair are slightly higher than the outer ones; surface of both central and lateral cones very strongly striated.

This beautiful species strongly resembles in general appearance *C. acutus* and *C. mirabilis*, of Agassiz (described in the *Poissons Fossiles*, Tome III., pp. 197, 199, Plate 22, Figs. 9, 13-21), but differs from both in having the internal pair of secondary cones as large as, or larger than, the outer pair. In this respect it is unlike any other species known to me, except *C. Hertzeri*, described on another page.

This remarkable tooth was found by Dr. C. Rominger, in a calcareous sandstone of Waverly age, at Battle Creek, Michigan. To his kindness I am indebted for an opportunity of examining it; a courtesy which I take pleasure in acknowledging by attaching his name to it.

It has not been possible to have drawings made of it in time for publication in this volume.

POLYRHIZODUS MODESTUS (n. sp.).

Plate LVIII., Figs. 10, 10 a.

Teeth small, largest half an inch in breadth and height. Crown surface 2 lines wide, much depressed, terminating posteriorly in an acute edge; root broad, and divided below into five or six flattened radicles.

Of this little tooth only one complete specimen has yet been found. This, with fragments of others, give fairly well the character of the species and show it to be distinct from any other yet described.

In the Report of the Geological Survey of Illinois, Vol. II., several species of *Polyrhizodus* are figured and described, all indeed, with one exception, that have been heretofore met with in this country. By comparing the figure now given with those in the Report referred to, it will be seen at a glance that the tooth before us is so different that no detailed comparisons are required.

Formation and Locality: Cleveland shale, Bedford, Cuyahoga County, Ohio.

ORODUS VARIABILIS (n. sp.).

Plate LVIII., Figs. 11, 11 h.

Teeth of various forms and dimensions, the largest 15 lines in breadth, 5 lines in height and $2\frac{1}{2}$ lines in thickness; the crown on the posterior face forming half the height of the tooth, rising in the

center into a conspicuous boss, from which the surface falls off with several gentle undulations to either end. The enameled surface is highly polished but finely punctate throughout; on the posterior face of the central tubercle are a few fine radiating carinations. The enamel folds at the base of the crown form, on the posterior face, a relatively broad but irregular band; on the opposite face a more sharply-defined, single raised line. The root is flattened, pitted, and beveled on its lower edge. This variety is represented in Figs. 11-11 *b*. A second variety is indicated by Figs. 11 *c*-11 *f*. This is 12 lines long and very much flattened, the crown showing several rudimentary tubercles, of which the most conspicuous is nearer one end of the tooth than the other. Still another form is half the size of those already mentioned and more symmetrical, the central cone more prominent, the surface smoother, etc. (Figs. 11 *g*, 11 *h*).

All these, with many other specimens, were found so associated together that it cannot be doubted that they formed the dentition of a single individual. Their diversity of form and size shows very plainly the liability to multiply species when describing detached teeth.

With these teeth are quantities of dermal tubercles, which doubtless belonged to the same fish that bore the teeth. These tubercles are generally elongated and have the enameled surface strongly marked with revolving ridges and furrows. In the same stratum and in immediate proximity to these teeth, were found spines of two species of *Ctenacanthus* (*Ct. formosus* and *Ct. furcicarinatus*), and teeth of *Cladodus Pattersoni*. With one of these spines the teeth under consideration undoubtedly belong; and as the *Cladodus* is a very small species, we may conclude that *Orodus* and *Ctenacanthus* are only parts of the same genus.

Formation and Locality: Black shale of Waverly Group, Sciotoville, Ohio, and Vanceburg, Ky.

ORODUS ELEGANTULUS. N. AND W.

Plate LVIII. Figs. 12, 12 *a*.

A small and very neat species of *Orodus* which occurs rarely in the Cleveland shale at Bedford, Cuyahoga County, is so much like that described by Mr. Worthen and myself in the Illinois Report, under the above name, that I have regarded it as probably the same. Some of the specimens found, like that now figured, have all the essential characteristics of those from Illinois, except that they are less arched; while other and smaller teeth have sometimes the median cone somewhat pyramidal, and

obtuse *points* occur between that and the ends. These may belong to another species, but the material at hand does not justify us in separating them from the forms which have been found at the West.

Orodus elegantulus occurs in Illinois, in the Burlington limestone.

CTENOPTYCHIUS SEMICIRCULARIS. N. AND W.

Plate LVIII., Fig. 14.

A single tooth of this species was found in a Coal Measure limestone, Adams Township, Muskingum County, O., by Professor J. J. Stevenson. It is rather less arched than most specimens of the species, but, in other respects, is undistinguishable from many which I have from the Coal Measures of Indiana and Illinois.

Teeth generically identical with these, and with difficulty distinguishable specifically, are common in the Carboniferous limestone of Armagh, Ireland. These have not yet been described, but were named by Agassiz *Ctenoptychius dentatus*. He subsequently referred them, in his MS. catalogues, to the genus *Harpacodus*, created to receive them; still later to a new genus, *Peripristis*. The latter name has been adopted by Mr. O. St. John, who gives a definition of the genus in Dr. Hayden's "Final Report on the Geology of Nebraska," p. 242. I find it impossible, however, to recognize more than specific differences between these teeth and those which form Prof. Agassiz's type species of *Ctenoptychius* (*Ct. serratus*).

From the Crinoidal limestone of the Lower Barren Measures, in the city of Pittsburgh, I have a single tooth which is closely allied to, but distinct from, those under consideration. In this specimen only a part of the crown is shown. This is much flatter than that of *Ct. semicircularis*, the denticles larger and symmetrically lance-shaped, and the whole surface covered with a fine, crape-like wrinkling, instead of being highly polished, as it is in the other specimens from America and Ireland.

PETALODUS ALLEGHANIENSIS, Leidy.

Plate LVIII., Figs. 13, 13a.

The Crinoidal limestone, which is a very constant member of the Lower Barren Coal Measures of Ohio, has furnished so many fish teeth that it deserves to be specified as one of the "fish beds" of the State. Most of the fish remains of this horizon are small and usually imperfect shark's

teeth, among which are species of *Petalodus*, *Cladodus*, and *Ctenoptychius*.

Of these the largest and most abundant belong to a species of *Petalodus*, which seems to agree in all respects with *P. Alleghaniensis*, described by Dr. Leidy, and first obtained from the Coal Measure limestones of Pennsylvania. Two of these teeth are now figured, and they represent fairly well the size and forms of the specimens found. It will be noticed that in one of these the crown is higher, and the root larger than in the other. These differences are not constant, however, and can hardly have specific value. They are probably due to the positions held by the different teeth in the extended series which formed the dentition of the fish to which they belonged.

In the Report of the Geological Survey of Illinois, several species of *Petalodus* are described, one of which, *P. destructor*, is from the Coal Measures. From its large size and peculiar root, this tooth was considered distinct from *P. Alleghaniensis*, but Mr. O. St. John, who has given much study to the fish teeth found in Illinois and Iowa, regards them as identical. This seems to me probable, but it is not yet proved by any facts which have come under my observation. None of the specimens of *P. Alleghaniensis* yet found in Ohio are more than half as large as some of those from Sangamon County, or from Cassville, Illinois. They differ too, in the form of the root; the specimens from Ohio having more elongated and narrower roots than the great teeth, with spatulate, pointed roots, which are found in the Coal Measures of Illinois. These differences may be only local, however, and it is quite possible that intermediate forms will hereafter be found which shall connect the robust and powerful teeth of the West, with the smaller and more delicate forms which occur in the Crinoidal limestone of Ohio.

CTENACANTHUS FORMOSUS, Newb.

Plate LIX., Figs. 1-1e.

This fine species of *Ctenacanthus* is described in Vol. I., Part II., p. 328, of this Report. The figure now given is taken from a very perfect specimen obtained by M. C. Read, Esq., from the Cuyahoga shale at Warren, Trumbull County. It illustrates the size, form, and markings better than the figure before given, and much better than any verbal description could do. During the progress of the Survey, more or less perfect specimens of this species were met with in various parts of the State, where the Waverly rocks were exposed, and it is evident that the shark which bore them was the most common, and probably the most formidable of those

which here inhabited the shallows of the incoming sea of the Carboniferous age. In the limestones which form the open sea deposits of this age, no traces of this fossil have yet been discovered. In the specimen from which the drawing was made for the figure now given, the denticulation is remarkably regular and exact. The lithographer has, however, failed to represent this with accuracy.

CTENACANTHUS FURCICARINATUS (n. sp.).

Plate LIX., Figs. 2-2 c.

Spine of medium size, robust; 8 to 10 inches long, $1\frac{1}{4}$ inches wide. Section near summit compressed, with flattened and nearly parallel sides, near base oval. Basal portion smooth or longitudinally striated, rounded below and thin from the expansion of the medullary cavity. Line separating the plain from the ornamented surfaces very oblique and sigmoidally curved. Exposed portion of spine covered with numerous strong, more or less flattened and pectinated longitudinal costæ, many of which are dichotomously forked near the base.

Toward the summit of the spine, there are about 15 of these costæ. Near the base they are much more numerous from bifurcation. Those near the anterior and posterior margins are fine, those occupying the middle of each side more than twice as broad. The posterior face is flattened so as to form a distinct angle with the sides, but is raised along the median line in a strongly-marked but rounded ridge.

The most striking features in this spine are the obliquity of the line of contact between the exposed and buried portions, the bifurcation of the rounded longitudinal ribs, and the general, but inconspicuous pectination. This is well shown in the enlarged view of three of the costæ given in Plate LIX., Fig. 2 c.

These spines are found so associated with the teeth of *Orodus variabilis* as to make it extremely probable that they belonged to the same fish. There are also found with them quantities of dermal tubercles which are undoubtedly those of this species of *Otenacanthus*. Some of these are represented, somewhat enlarged, in Fig. 4. They are obscurely rhomboidal in outline and marked with a few coarse furrows and ridges. From the association of these fossils we are justified in concluding that we have in them the teeth, spines, and dermal tubercles of one of the sharks that inhabited the Lower Carboniferous seas. These are all the really bony portions of most Selachians and all that are generally fossilized; but with these, in the present instance, are numerous traces of

organs which, under all ordinary circumstances, have disappeared, viz., the tail and fins. In some cases almost the perfect outlines of sharks six or more feet in length are said have been found by the quarrymen traced upon the surfaces of shale. One of these specimens represents the heterocercal tail of a large shark in which the vertebræ have entirely disappeared, leaving a smooth band representing the vertebral column. On either side of this, however, the outlines of the interspinous bones are distinctly traced; but the most remarkable thing about this fossil is that the lower lobe of the tail consists of rays that were distinctly ossified and now retain their original positions and forms. This indicates that these old, Carboniferous sharks were as highly organized as any of those inhabiting the present seas.

No similar instance of the preservation of the soft parts of cartilaginous fishes is known to me except that of *Chondrosteus* in the marls of the Lias of England. In both these cases the unusual preservation of the remains is probably due to the comparatively rapid deposition of an earthy carbonaceous sediment over them. In the formation of limestones, derived exclusively from organic structures, the accumulation of material on the sea bottom must necessarily have been exceedingly slow, and the soft parts of aquatic animals deposited with it have been so exposed to decay, and to the depredations of the various forms of marine life that subsist upon such food, that they have been totally destroyed.

Formation and Locality : Black shale of Waverly Group, Vanceburg, Ky.

CTENACANTHUS PARVULUS (n. sp.).

Plate LIX., Fig. 3.

Spine very small, 1 to 2 inches in length by 2 to 3 lines wide; basal portion relatively broad and long, flattened, irregularly striated; exposed portion slightly curved, acute, compressed, but arched transversely; surface covered with relatively broad, but somewhat irregular longitudinal ridges. Posterior face set with large and much depressed hooks.

This little spine is referred to *Ctenacanthus* with some doubt, as the longitudinal ribs show no tubercles or scales such as are usually found in the species of this genus. It agrees with them, however, in the generalities of its form and markings, and scarcely affords material for the creation of a new genus.

In the figure now given the longitudinal ribs are too strong and continuous.

Formation and Locality : Cleveland shale, Bedford, Ohio.

LISTRACANTHUS HYSTRIX, N. AND W.

Plate LIX., Fig. 5.

The species represented in the figure cited above, is very common in the Coal Measures of Indiana and Illinois, though but rarely seen in Ohio. It will be found described in the Geological Report of Illinois, Vol. IV., p. 372, Plate XI., Figs. 3, 3a. In Indiana these spines occur so frequently with the dermal tubercles of *Petrodus* that they are generally supposed to belong to the same fish. While this may be possible, it should be said that we have never yet found the tubercles of *Petrodus* in Ohio, while *Listracanthus* is not unknown here.

Formation and Locality : Black shale over Coal No. 6, Perry County, Ohio.

LISTRACANTHUS HILDRETHI (n. sp.).

Plate LIX., Fig. 6.

Spine of relatively large size ; nearly 6 lines broad, 2 inches from the summit ; curved and sharply carinated, carinæ slightly granular ; convex side strongly squamose.

Only a single specimen of this spine is known, and that lacks the basal portion. It is sufficient, however, to show that it was much broader, more curved, and more strongly and sharply marked than even the largest specimens of the common species, *L. hystrix*.

Formation and Locality : This specimen was found near Marietta, by the late Dr. S. P. Hildreth, and is now in the Cabinet of Marietta College.

ORTHACANTHUS GRACILIS (n. sp.).

Plate LIX., Fig. 7.

Spine small and straight, about three inches long, very slender and acute ; section circular at base, posterior face and sides flattened above ; the angle inclosed by them set with acute, recurved, compressed denticles throughout the upper two-thirds of the entire length ; surface smooth or very finely striated longitudinally.

These delicate spines might be supposed to represent the immature state of *O. arcuatus*, but it is hardly supposable that they should have

become so decidedly arched in subsequent stages of growth, as the latter spines are. As it is now generally believed that the spines of *Orthacanthus* were worn by the sharks of which the teeth are called *Diplodus*; and as at least two species of *Diplodus* are found at Linton, it is highly probable that the curved and straight spines were associated respectively with these different teeth. When found in connection with the teeth so as to fix the relationship between them, the names now given to these spines may be suppressed. Until such relationship shall be determined, however, it will serve a useful purpose to describe them under distinct names.

Formation and Locality: Coal Measures, Linton, Ohio.

GENUS GYRACANTHUS, Agass.

Since the publication of the descriptions of the species of *Gyracanthus* found in Ohio (Vol. I., Part II., p. 330), I have received a letter from Mr. D. Honeyman, of Halifax, in which it is stated that the great spine figured by Prof. Dawson (Acadian Geology, 2d Edition, p. 210), and named by him *Gyracanthus magnificus*, was taken by Mr. Honeyman from the *Lower Carboniferous limestone* of Baddeck, Cape Breton, and not from the Coal Measures, as I inferred from Prof. Dawson's notes. This case, therefore, instead of forming an exception to the rule to which I have referred, viz., that the spines of *Gyracanthus*, while common in the Coal Measures of Europe, in America have only yet been found in Lower Carboniferous rocks, affords another illustration of it. We should not be justified in saying that *Gyracanthus* did not exist in America during the Coal Measure Epoch, for it may be any day found in the coal strata; but it is an interesting fact that, up to the present time, no traces of it have been seen in this country in other than Lower Carboniferous rocks.

In letters received from Sir Philip Egerton since the publication of my notes on *Gyracanthus*, it is stated that it has been demonstrated that many of the spines of *Gyracanthus* found in Europe were attached to the pectoral fins, and that some of these are much worn, as though by contact with the bottom of the sea in which this shark lived.

These facts are cited by Sir Philip Egerton as confirmatory of the view presented in my notes, that the spines of *Macheracanthus* belonged to the pectoral fins.

GENUS PLATYODUS (nov. gen.).

Teeth elliptical in outline, crown slightly arched in both directions, surface punctate in undulate lines, but without folds or ridges.

Nothing is known of this genus except what is taught by a single specimen, which forms the basis of the specific description given below.

It is evident that it was once worn by an ancient Elasmobranch fish allied to *Deltodus*, *Sandalodus*, etc., but distinctly separated from them by its rounded outline, simple margin, low, evenly-arched crown, and linear punctation. How many teeth were borne on the jaws, and how much varied in form they were, if more than two, will doubtless be determined by future discoveries.

PLATYODUS LINEATUS (n. sp.).

Plate LIX., Fig. 12.

Teeth broad and low, ovoid or elliptical in outline, 3 inches long by $1\frac{1}{2}$ inches wide; crown surface gently arched in both directions, punctate throughout, punctations arranged in broadly undulate lines which cross the crown transversely.

The only tooth of this fish yet known was found by the writer in the Waverly shales, on the farm of Mr. Dunn, eight miles south of Liberty, Casey County, Ky. It is somewhat worn by use, and corroded by exposure, but still exhibits characters by which it may be distinguished, at a glance, from any other heretofore described. Of these characters the most conspicuous are its great size, low, doubly-arched crown, without ridges or furrows, and the undulate lines of punctæ which occupy all the surface.

HOLOCEPHALI.

CHIMÆROIDI.

GENUS RHYNCHODUS, Newb.

The announcement made in our first volume that the remains of Chimæroid fishes had been discovered in the Devonian rocks of Ohio, and the reference of the genus *Rhynchodus* to this family, may have excited some surprise and perhaps incredulity, as Chimæroids had not before been

found in rocks older than the Jurassic. I am happy to be able to say, however, that the views there expressed in regard to the zoological relations of this genus are fully confirmed by Sir Philip Egerton, who has made a special study of the Chimæroids, living and fossil, and is confessedly the highest living authority in all that relates to their structure and classification. He writes me that the teeth described in Vol. I., Part II., pp. 307-313, under the name of *Rhynchodus*, are unquestionably those of Chimæroid fishes.

PTYCTODUS CALCEOLUS, N. AND W.

Plate LIX., Figs. 13, 13 a.

A tooth which probably belongs to the same species with that now figured, was described in the Illinois Geological Report, Vol. II., p. 106, Plate X., Fig. 10, under the name of *Rinodus calceolus*. This name was subsequently (Vol. IV., p. 374) changed to that given above, as it was discovered that the tooth designated by it came within Pander's genus *Ptyctodus*.

During the past year I have received from Mr. A. S. Tiffany, of Davenport, Iowa, the specimen of which a figure is now given. This is longer and narrower than that described in the Illinois Report, and the triturating surface instead of being depressed or sunken into the crown of the tooth, as in the Illinois specimen, is distinctly raised above the general surface. This difference is, I suspect, due to the fact that one is an upper and the other an under tooth; the elevated portions of one fitting into the depressions of the other.

As stated in the description contained in the Illinois Report, I suppose these to be the teeth of Chimæroid fishes.

Formation and Locality: Hamilton Group, Davenport, Iowa.

GANOIDEI.

DIPTERINI.

GENUS CTENODUS, Agass.

CTENODUS SERRATUS (n. sp.).

Teeth of lower (?) jaw of medium size, 16 lines long by 9 lines wide, somewhat triangular in outline; crown marked with eight prominent and

sharp radiating ridges, which terminate above in numerous compressed, acute denticles; the furrows between the ridges being pitted to receive corresponding denticles of the opposite teeth. These ridges and furrows vary much in length, so that one end of the tooth forms a long pointed triangle, and at the opposite extremity the crown is rounded and the base projects in a depressed and flattened point.

In general form and marking this tooth bears considerable resemblance to that of *Ct. obliquus* of the Northumberland coal-fields, England, but the ridges are more numerous and much narrower. From the larger species of *Ctenodus* found in England, *Ct. tuberculatus*, etc., it will be at once distinguished by the fan-like radiation of its ridges, which all centre at the most prominent point of the crown. When in its perfect condition this is the most elegant species of the genus yet discovered. It is characterized by a remarkable exactness of form and sculpture. The internal margin forms a graceful arch from which the prominent point of the base projects at the end of the tooth where the ridges are shortest. The denticles which crown the ridges are much compressed, very sharp, and somewhat curved outward.

Fig. 15 represents a tooth of the lower jaw seen from above; 15a, one of the ridges in profile; 16, a small, triangular tooth probably from the upper jaw of a smaller individual of the same species.

In the Report of Prof. E. D. Cope, contained in this volume, will be found a figure and description of a portion of a large cranium of what is supposed to be a species of *Ctenodus*, found at Linton. A more complete cranium of the same kind, which I have, is about 8 inches in diameter, and the teeth which were once connected with it must have been considerably larger than any yet found at Linton. Prof. Cope calls his species *Ct. Ohioensis*. Whether it is identical with either of the species I have named from the teeth is not yet known.

Formation and Locality : Coal Measures, Linton, Ohio.

CTENODUS RETICULATUS (n. sp.).

Teeth of medium size (15 lines long, by 10 lines wide); general outline triangular, the inner margin arched. Crown marked with 7 low, radiating ridges, of which the summits form zigzag salient lines. The whole crown of the tooth exhibits a fine reticulated ornamentation, which on the ridges is more or less radiate, and has the appearance of *hachures*.

The only specimen of this species yet found is too imperfect for figuring or full description. The characters given above will, however, serve

to distinguish it at a glance. The ridges are also broader and fewer in number than in *Ct. serratus*, while the zigzag lines of the summit and the vermicular ornamentation of the surface, present features that are not found in any other known species. In most of the teeth of *Ctenodus* the crown surface is smooth, and the acute denticles which crown the ridges are highly polished.

Formation and Locality : Coal Measures of Linton, Ohio.

DIPTERUS SHERWOODI (n. sp.).

Plate LVIII., Figs. 17, 17 *a*, 17 *b*.

Teeth one inch in length, triangular in outline; crown marked with three prominent tuberculated ridges, separated by deep furrows somewhat wider than the ridges. The strongest of these ridges forms one side of the triangular tooth. On the angle opposite this side are a few irregular tubercles but no traces of distinct ridges. The denticles which crown the ridges are somewhat compressed laterally, are rounded, smooth, and blunt at the summit.

This is apparently one of the upper palate teeth of a species of *Dipterus*, and is specially interesting, as being the first relic of that genus found on this continent. It can be readily distinguished from all the species described abroad, by the small number of its radiating ridges. This specimen is from the Catskill group of Tioga County, Pa., and was discovered by my former assistant, Mr. Andrew Sherwood, now of the Geological Corps of Pennsylvania, to whom I am indebted for an opportunity of examining it.

In the same rock with this tooth are a number of imperfectly preserved rhomboidal, or rounded scales, which are thick and strong, and have the upper surface punctate precisely as in the scales of the foreign species of *Dipterus*. The surface of these scales was, probably, once highly polished, but like all the fish remains of the Catskill, the organic tissue seems somewhat corroded.

It is a singular fact, that while previous to last year, no teeth of Dipterians had been found in this country, both *Ctenodus* and *Dipterus* were almost simultaneously discovered; one in the Coal Measures of Ohio, the other in the Catskill of Pennsylvania. More material is wanted for comparing the fishes which now bear the names of *Ctenodus* and *Dipterus*, but, judging from the teeth alone, they might, with propriety, be included in one genus. It is true that no scales have been found in the Coal Measures which could be referred to *Ctenodus*, and it is quite possible that the

Carboniferous species yet known, were without scales, but the same difference probably existed between the *Ceratodus* of the Trias, and the "Barramunda" of Australia; both of which have been included by Dr. Gunther in the same genus. No scales have been found in connection with the Triassic teeth, while the Australian *Ceratodus* has the body covered with large imbricated scales.

Fig. 17 represents the tooth of the natural size, seen from above. Fig. 17 *a*, a side view of the same, and Fig. 17 *b*, a profile view of the marginal row of denticles.

GENUS HELIODUS (nov. gen.).

A Ganoid fish, closely allied to *Dipterus*, from which it differs in having the upper palate teeth united together to form a single large rounded, or semi-circular triturating plate, bearing several tuberculated ridges which radiate symmetrically on either side of the central line. These ridges are highest on the margin of the tooth and gradually diminish to the centre, which is smooth. The dental plates of the lower jaw have not yet been found. Whether they were consolidated in one, or separated like those of *Dipterus* is not yet known. Since, however, they were in *Dipterus* and *Ctenodus* more widely separated than the upper teeth it is possible that they were not joined together in *Heliodus*. In microscopic structure this tooth is similar to those of *Dipterus*. The tuberculation of the ridges is precisely the same, and if divided through the middle, each half would be accepted as one of the upper dental plates of that fish.

There is little doubt that we have in *Heliodus* a new member of the family of Dipterine Ganoids to which *Dipterus*, *Ctenodus* and *Ceratodus* belong, and its dental plates present a simple but hitherto unknown modification of the characteristic dentition of the group. In the other genera of the family the palate teeth vary much in form and in the number and character of their radiating ridges. In *Dipterus* the upper teeth have the form of right-angled triangles, or half opened fans, the ridges being set with rounded and generally obtuse tubercles. The lower teeth are longer, like a fan two thirds opened. In *Ctenodus* the number and form of the teeth is the same as in *Dipterus*, but the radiating ridges are generally more compressed, and the tubercles are more acute. In *Ceratodus* the teeth are smooth, the ridges few and large, and without tubercles. Finally in *Heliodus* we have the upper pair of palate teeth firmly joined in one plate, taking the form of a fully opened fan, and bearing radiating tuberculated ridges like those of *Dipterus*.

In the "Bulletin of the Royal Academy of Belgium" (2^e *Serie*, t. XXVII. p. 385), P. J. Van Beneden describes the palate tooth of a fish, which is without much doubt, generically identical with that on which the above description is founded. It differs, however, from that here described in having five tuberculated ridges, instead of four, on either side of the median line, in the number of tubercles on the ridges, and most of all in size: for the Belgian tooth is eight inches in diameter. M. Van Beneden considers his specimen as generically identical with a fish described by M. De Koninck and himself, in a preceding volume of the "Bulletin of the Royal Academy of Belgium" (2^e *Serie*, t. XVII., p. 143), and which was made the type of a new genus (*Palæodaphus*). This remarkable fossil was found in the Carboniferous limestone of Belgium, and was considered by the distinguished authors of the paper referred to, as a portion of the head and upper jaw of a Plagiostomous fish, having some resemblance to *Squatina*.

Excellent figures of both fossils were published by Van Beneden and De Koninck; and judging from these and the minute descriptions which they give, I am compelled to dissent from their view of the generic identity of their two species of *Palæodaphus* (*P. Insignis* and *P. Devonienensis*).

The first seems to me, as to them, a portion of the head of a large Plagiostome, but the second exhibits characters which lead me to conclude that it is the palate tooth of a Dipterian Ganoid, and that it belongs to a genus that required a new name and description. These I have ventured to supply in describing the American specimen recently found; uniting it with the Belgian species ("*Palæodaphus Devonienensis*"), in the genus *Heliodus*.

My reasons for considering these the teeth of Ganoids and not of Selachians are that they have essentially the structure of those of *Dipterus*,—i. e., are composed throughout of true bone, and bear radiating ridges crowned with tubercles, of which the summits are coated with enamel—and no such structure is known to exist in any Elasmobranch fish. In all the members of this order the jaws are cartilaginous, and the teeth are united to them by mere ligamentous attachments.

If I am correct in separating generically the two species of *Palæodaphus*, that described by Van Beneden under the name of *Palæodaphus Devonienensis* becomes *Heliodus Devonienensis*; and if the view now advanced in regard to the zoological relations of *Heliodus* is the true one, we have in *H. Devonienensis* by far the most gigantic member of the Dipterian family yet known, and one that must have rivalled in dimension *Dimichthys*, the largest of the other great branch of the Ganoid order, the Placoderms.

HELIODUS LESLEYI (n. sp.).

Plate LVIII., Fig. 18.

Upper dental plate rounded or hippocrepiform, $1\frac{1}{2}$ inches in length and breadth; triturating surface more than a half circle, highest in the centre, where it forms a broad smooth boss; from this radiate eight tuberculated ridges, four on either side of the median line, which is marked by a deep and smooth furrow. The ridges on each side differ among themselves, but are symmetrical with those on the other side, the lateral ridges being shortest, and bearing several tubercles, while the pair which borders the central furrow have but a single tubercle at the extremity of each. On both sides of the central boss the crown of the tooth is worn in a shallow, rounded depression by the opposing teeth of the lower jaw. The posterior margin of the crown is nearly straight, and is slightly crenulated at the centre. This is bordered by a sloping surface which extends downward and backward about four lines, and expands laterally to form low, winglike projections. This portion of the tooth was doubtless covered with integument.

The more important features of this tooth and its relations to allied forms, are given in the generic description. It was obtained by Mr. Andrew Sherwood, in the Upper Chemung rocks of Northern Pennsylvania, and is named in honor of Prof. J. P. Lesley, the Director of the Geological Survey of that State.

GEOLOGICAL SURVEY OF OHIO.

VOL. II. PART II.

PALÆONTOLOGY.

SECTION I.

DESCRIPTIONS OF INVERTEBRATE FOSSILS, MAINLY FROM THE
SILURIAN SYSTEM.

BY

JAMES HALL AND R. P. WHITFIELD.

DR. J. S. NEWBERRY, *State Geologist*:

DEAR SIR: In accordance with your expressed desire that the descriptions of Ohio fossils, scattered through various publications, and in many cases inaccessible to the general student in science, should be brought together in a classified form, with illustrations of the same, the accompanying descriptions and figures are offered as a contribution in that direction. This work is necessarily incomplete, both from want of time and for the want of means of illustration for the entire series. Under these circumstances it was thought better to confine the work mainly to the fossils of the Hudson River, Clinton, and Niagara groups inclusive, giving, with the described species, such new forms from the Ohio localities as might come under observation during the progress of the work. But with this restriction it has been found necessary to leave out some entire groups which it would be very desirable to illustrate, and which have not yet been described or illustrated in any American publication. These are especially the Bryozoa and Corals of the Cincinnati beds and their equivalents in other parts of the State, among which are many characteristic species requiring much time for study, with careful descriptions and illustrations, to make them available for the use of the student in Palæontology.

In the outset it was proposed to give the same revision to the higher groups that has been partially given to the lower; the figures of the Crinoidea from the Waverly group were made in pursuance of that plan, but it afterwards became apparent that the time and means at our disposal were insufficient for the work, and in consequence nearly every thing from the age of the Corniferous, Hamilton, Portage, and Chemung groups have been omitted from the present communication.

During the progress of the work interesting specimens have been received from Mr. U. P. James and Mr. S. T. Carley, of Cincinnati, from Mr. Jesse Vanduzer, of Waynesville, and President Edward Orton, of Columbus, Ohio, to whom we are under especial obligations. Several other gentlemen of Cincinnati, Dayton, and other places, have kindly offered to contribute specimens, but the necessity of restricting the limits of the work has prevented us from accepting their assistance in this direction on the present occasion.

Very respectfully, your obedient servants,

JAMES HALL,

R. P. WHITFIELD.

FOSSILS OF THE HUDSON RIVER GROUP.

(CINCINNATI FORMATIONS.)

BRACHIOPODA.

GENUS LINGULA, Bruguiere.

LINGULA COVINGTONENSIS (n. sp.).

Plate 1, fig. 1.

Shell rather below the medium size, broadly and very regularly oval, or elliptical in outline, the breadth and length being as three to four, the apex of the shell scarcely more pointed than the basal margin; surface of the valve very regularly convex transversely, but in a longitudinal direction much more prominent toward the beak, becoming gradually more flattened toward the front of the shell.

Surface of the shell marked by sharply elevated, rather distant, concentric lines; without other markings of any kind; substance of the shell very thin.

The example used in description appears to be a dorsal valve, and is probably somewhat shorter, and more rounded posteriorly, than the ventral valve. The shell is somewhat remarkable for its regular oval form and symmetrical outline, and in this respect differs from any shell of the genus with which we are acquainted.

Formation and locality: In the Hudson River group, twenty-five to fifty feet above low-water mark, opposite to Cincinnati, Ohio. Collection of U. P. James, Esq.

GENUS LINGULELLA, Salter.

LINGULELLA (DIGNOMIA?) CINCINNATIENSIS (n. sp.).

Plate 1, figs. 2, 3.

Shell above the medium size, sub-angularly ovate in outline; the lateral margins of the valves gradually converging from the point of greatest width, near the lower end, for about one-fourth of the entire length of the shell, measuring on the dorsal valve; from this point the border

slopes rapidly to the obtusely rounded beak; basal or front margin broadly rounded. Beak of the ventral valve projecting a little beyond that of the dorsal; the edges of the cardinal border strongly and abruptly inflected, forming an area along the entire cardinal portion of the valve, and leaving the outer margin of this portion of the valve saliently angular. Under the beak, and extending across the area to the beak of the dorsal valve, there is a rather small, slightly raised, and moderately convex deltidium, which does not appear to have been separable from the other portion of the shell, so far as can be determined from the material in hand. (The precise nature of this deltidial piece is not fully determined.) Border of the dorsal valve also slightly inflected at the apex, and for a short distance below on both sides, but not forming an area as on the ventral valve.

Surface of the valves convex, the ventral most ventricose; sometimes marked by scarcely defined angulations, extending from near the apex of the valves to the lateral angles of the basal border. Other specimens have the surface evenly convex, or marked along the center of one or both valves by a broad, shallow depression. Dorsal valve most prominent and ventricose near the beak.

Surface of the shell marked by fine, closely arranged, irregular, concentric, depressed lines; not lamellose, but leaving the spaces between the several lines flat, or slightly rounded. The surface not otherwise marked or sculptured, but smooth and polished. The interior of the valves are each marked by a strong, rounded, longitudinal ridge, extending nearly one-half the length of the valve, and usually situated about half as far from the cardinal extremity as from the basal border. The muscular markings are very large, extending over a large portion of the surface, but on the specimens examined, not quite distinct enough for description.

This shell has usually been referred to *Lingula quadrata*, Eichwald, but is in reality a very different and distinct species. The form of Eichwald's species, judging from the best figures to which we have access, is broadly elliptical, more distinctly rounded at the base, and less angular at the rostral end, with a less pointed beak, and the lateral margins of the shell sub-parallel. Almost the same differences are noticed when compared with the New York shells referred to that species, they having nearly or quite the characters of the European shell.

There may be some doubt as to the proper reference of the species to Salter's genus *Lingulella*. The presence of the narrow cardinal area, although not exactly of the nature of that of *Lingulella*, precludes the pos-

sibility of its being a true *LINGULA*; and the strong mesial ridge along the interior of the valves would seem to separate it entirely from the former genus. But as the material now in hand is not entirely satisfactory, we prefer to refer it to *Lingulella*, as we are not certain in what particulars it may differ from the genus *DIGNOMIA*.

Formation and locality: In the shales of the Hudson River group, at Cincinnati, Ohio. Collection of U. P. James, Esq.

GENUS *LEPTOBOLUS*, Hall.

LEPTOBOLUS LEPS.

Plate 1, figs. 10, 11.

Leptobolus lepis, Hall; Descr. of New Species of Fossils from Hud. Riv. Gr., etc., Oct., 1871, p. 3.

Leptobolus lepis, Hall; 24th Rept. State Cab., p. 226, pl. 7, figs. 19, 20.

"Shell minute, ovate, or broadly elliptical in outline, about three-fifths as wide as long, and seldom exceeding seven hundredths of an inch in length; moderately convex, the greatest convexity about one-third of the length from the beak; ventral area thickened; pedicel groove strongly defined; muscular impression broad, extending more than one-third the length of the valve; muscular ridges of the dorsal valve strongly marked, the central one extending two-thirds the length of the shell, the lateral ones diverging from each other at an angle of about forty-five degrees, and extending nearly to the middle of the valve; extremities bifid."

"Surface of valves concentrically marked by fine lines of growth."

The specimens of this species are minute scale-like bodies, found scattered over the surface of the layers in certain beds of the formation, and are easily overlooked, except by those accustomed to the forms usually found in the formation. They are an exceedingly interesting group of shells, from the fact of their apparently gregarious habits, and the great numbers of individuals usually found associated in localities where they occur. The same habit appears to have prevailed among the other species of the genus, so far as yet observed.

Formation and locality: Shales of the Hudson River group, at Cincinnati, Ohio. The original specimens were from the collection of Mr. C. B. Dyer.

GENUS TREMATIS, Sharpe.

TREMATIS MILLEPUNCTATA.

Plate 1, figs. 4-7.

Trematis millepunctata, Hall; Ext. 20th Rept. State Cab., p. 14, 1866.*Trematis millepunctata*, Hall; 24th Rept. State Cab., p. 221, pl. 7, figs. 22-25.

Shell small or medium sized, sub-orbicular, slightly transverse on the ventral side and lenticular in profile. Ventral valve strongly convex below the middle, more depressed above, and with a narrow, deeply depressed pedicle-opening extending to the cardinal border, the margins being flattened for a space nearly equal to the breadth of the opening. Dorsal valve more elongated than the opposite, most convex above the middle; beak pointed, and projecting considerably beyond the cardinal margin of the ventral valve, and having a depressed or concave triangular area.

Interior of the dorsal valve marked near the middle by two comparatively large, semi-circular or reniform muscular scars; the breadth across the two more than equals one-third the diameter of the valve, and in the center of the valve by a slight mesial septum.

Surface strongly punctate in concentric curves passing from the center of the shell outwards, extending through the substance of the shell near the front margins of the valves, and distinctly marking the internal casts left by the decomposition of the shell; inner layers of the shell not punctate.

This species has been commonly identified with *T. terminalis*=*Orbicula terminalis*, Emmons. It differs, however, from that species in the more transverse form, less convexity of the ventral valve, and prominent beak of the dorsal; as also in not having the puncta passing entirely through the substance of the shell as they do in that species.

Formation and locality: In the shales of the Hudson River group, at Cincinnati, Ohio.

TREMATIS PUNCTOSTRIATA.

Plate 1, figs. 8, 9.

Trematis punctostriata; 23d Rept. State Cab., p. 243, pl. 13, figs. 17, 18.

The following is the description of this species as given in the 33d Report:

"Shell of medium size, oblate, with the rostral border somewhat protruding, giving a broadly oval form to the upper valve. Upper valve

convex, most prominent near the umbo; lower valve flat, transversely elliptical and strongly notched on the posterior margin; the notch extending two-thirds the distance from the edge to the center of the valve."

"Surface marked by distant, radiating, impressed striæ, which are indented along the bottom by distinct puncta. In exfoliated specimens neither the striæ nor puncta are visible, these being features of the exterior layer only."

"The puncta and distant striæ are features which distinguish this species from any other described."

There are several individuals of this species in the collection of Prof. J. Hall, from Cincinnati, Ohio, and a single lower valve has been noticed among collections received from U. P. James, Esq., of Cincinnati. The Ohio shells differ from the originals of the species (from the hydraulic limestones at Clifton, Tennessee, supposed to belong to the Trenton limestones) in being perhaps a little more circular in outline, or a little more elongate, and in having the notch of the lower valve much narrower. As the Ohio specimens are all either flattened or otherwise distorted, these differences may not hold good in more perfect individuals; we therefore prefer to consider them as belonging to the same species; especially as the structure of the shell and the lines of puncta are, so far as can be determined, perfectly identical.

Formation and locality: In the shales of the Hudson River group, at Cincinnati, Ohio.

GENUS SCHIZOCRANIA (new gen.).

Among the unarticulated brachiopods of the Silurian formation there is a group of radiatingly striated shells, which may be typified by *Orbicula ? filosa*, Hall, Pal., N. Y., Vol. I., p. 99, pl. xxx., fig. 9, which have usually been referred to the genera *Discina* and *Trematis*, but which do not exactly correspond in character to either of those genera. They differ from *Discina*, and also from *Orbiculoidea* (to which many of our Palæozoic Discinoid shells probably belong) in several particulars; among which may be mentioned the striated surface, the marginal beak of the upper valve, and the widely divided posterior margin of the lower valve, which forms a deep marginal notch, instead of an eccentric foramen or perforation, as in those genera. The lower valve in this group is firmly fixed and cemented to foreign substances, while those of the above genera are free, the whole being attached only by a byssus passing through the foramen of the lower valve. The substance of the shell is also of a much more calcareous nature, if not entirely so. To the genus

Trematis, Sharpe, they are more nearly related, both in the notched character of the lower valve, and in the marginal beak of the upper valve; but here their external similarity ends. The nature of the external markings is entirely different from all true species of that genus; the surface of the shells of this group being simply striated with radiating lines, while those of that genus are characterized by rows or lines of punctures, radiating or eccentric, passing through the outer layers of the shell. The great difference, however, is in the lower valve, and in their habits of growth. The species of *Trematis*, so far as can be determined from the typical forms, have been bysiferous shells, like those of *Discina*, attached to foreign bodies by a byssus or plug passing through the foramen of the lower valve, both valves being capable of considerable motion; never being permanently attached by their surfaces to foreign substances, but having a definite form characterizing each species. While these under consideration have been closely adhering bodies, like those of *Crania*, the lower valve being permanently attached to the surface of other shells or foreign bodies, by the whole lower side of the valve becoming fixed and united, and conforming in shape to the substance on which it grew. This feature is proved in *Orbicula ? filosa*, Hall, by numerous examples, most of those from Ohio being attached to valves of *Strophomena alternata*; and in one case no less than five individuals are seen grouped upon a single valve of that shell, all of which show parts of the lower valve, and all growing firmly to the shell, and conforming to it in curvature; three of the five retaining portions of the upper valve. Two other groups are known, of three in each group, attached to the same species of shell, and retaining parts of the upper valves more or less perfect. We are not aware of a single example from the formation at Cincinnati, Ohio, showing the two valves united, except in this parasitic condition. In the Utica slates, at Utica, New York, the upper valves of this species (*O. ? filosa*) are quite common, but the lower valve is very seldom seen; and among collections of scores of individuals from these slates, we know of only one group showing the lower valve. This group is clustered around the lower end of an *Orthoceras*, and among about thirty upper valves there are only thirteen lower valves seen, a few of which are not attached to the *Orthoceras*, but lie quite close to it.

The muscular markings of *Trematis* are not clearly understood; all that we know at present being two large, irregular formed imprints near the center of the upper valve. In the form under consideration there are six imprints known in the the upper valve, two of which are large, and situated near the rostral portion of the valve; two others, minute,

situated just below and between the lower ends of the former, with two medium sized circular ones near the center of the valve, and distant from each other. The external features and habits of the shells, however, certainly form strong distinctive characters, and ones of considerable more than specific importance, and upon these features principally we propose to separate them as a distinct genus, under the name of *Schizocrania*, hoping to be able, at no distant day, to illustrate more fully their internal characters.

The features as at present known are given in the following diagnosis:

GENUS SCHIZOCRANIA (new gen.).

Unarticulated, inequivalve, brachiopodous shells, growing parasitic on foreign bodies, to which they are attached by the close adhesion and anchylosis of the external or inferior surface of the lower valve. Lower valve flat or conforming to the surface to which it adheres; deeply notched on the posterior side of the center, the notch extending from a point more or less distant from the center of the valve to the posterior margin, where the sides of the slit are widely and distantly separated. Upper or free valve more or less convex, and having a beak terminal on the posterior margin. Surface of the upper valve radiatingly striated in the typical species; the lower valve concentrically wrinkled. Muscular imprints of the free valve, six known; two of which are situated near the rostral portion of the valve, large, ovate, and diverging; two minute, approximate, just below and between the former; and two of medium size, circular, distant from each other, and situated near the center of the valve. Those of the lower valve unknown. Type, *S. filosa* = *Orbicula ? filosa*, Hall. The striated surface, widely notched lower valve, and parasitic habits are the strong distinctive points.

The genus, so far as at present known, is confined to the Silurian formations.

SCHIZOCRANIA FILOSA.

Pl. 1, figs. 12-15.

Orbicula ? filosa, Hall; Pal. N. Y., Vol. I., p. 99, pl. xxx., fig. 9.

Trematis filosa, Hall; 23d Rept. State Cab., Expl. of pl. 13, figs. 21 and 22.

Shell orbicular, or very slightly ovate, the beak of the upper or free valve projecting a little beyond the limits of the circle, giving a somewhat greater diameter along the median line than in a transverse direction. Free valve moderately convex, the central region being the most

prominent. Attached valve discoid, very thin, deeply and broadly notched on the posterior side; the notch not extending quite to the center of the valve; occupying nearly one quarter of the circumference of the valve on the outer margin; border of the notch thickened, especially at the base, which is rounded, and the center marked by a slightly projecting point. Interior of the free valve marked by two proportionally large, elongate, ovate, diverging muscular prominences, leaving corresponding pits on the casts of the shell, or on exfoliated specimens; situated just below the beak, and extending to nearly or quite one-fourth of the length of the valve from the apex. There are also two other muscular impressions somewhat smaller in size, circular in form, and situated near the middle of the valve below the extremities of the ovate imprints, and slightly more distant from each other. Beneath the beak there is a slight thickening of the cardinal border. The muscular markings of the lower valve have not been observed.

Surface of the shell of the convex valve marked by fine, even, thread-like, radiating striæ; increased both by division and implantation, and gradually increasing in strength toward the border of the shell; the interspaces where the shell is perfectly preserved are flattened, the striæ appearing as raised lines on the surface. The attached valve is strongly marked by irregular concentric undulations circling the valve parallel to the margin, but interrupted at the border of the notch.

Formation and locality: In the Hudson River group in the vicinity of Cincinnati, attached to *Strophomena alternata* most frequently. Collection of U. P. James, Esq.

GENUS CRANIA, Retzius.

CRANIA SCABIOSA.

Plate 1, fig. 17.

Crania scabiosa, Hall; Ext. 20th Rept. State Cab., November, 1866, p. 13.

Crania scabiosa, Hall; 24th Rept. State Cab., p. 220, pl. 7, fig. 15.

Shell small, less than medium size, discoid or but slightly elevated, sometimes prominently and irregularly convex; irregular in outline, with thickened margins. Apex of the dorsal valve eccentric, varying in position in different individuals. Surface of the valves usually marked by strongly lamellose lines of growth, which are sometimes obscured by the roughness of the substance upon which they have grown, giving its character and form to the shell by causing it to grow irregular, so as to assume the feature of the body itself. Ventral valve thin, not preserving the muscular marking and other features of the interior in a condition for description.

The shells of this species are mostly found adhering to the surface of other forms of Brachiopods, and are by no means uncommon. They generally assume the surface features of the body to which they are attached to such an extent as to become almost unrecognizable when attached to coarsely marked surfaces, and are not unfrequently mistaken for adhering rock, and forcibly removed. When attached to shells having moderately sized plications, the upper valve of the *Crania* is found to conform in surface characters to that of the foreign body, the plications passing obliquely across the valve, and it is only when attached to comparatively smooth surfaces that the true features of the shell can be obtained.

Formation and locality: In the shales of the Hudson River group, at Cincinnati, and Waynesville, Ohio, and at several other places in the same formation outside of the State.

CRANIA LÆLIA.

Plate 1, fig. 16.

Crania Lælia, Hall; Ext. 20th Rept. State Cab., Nov., 1866, p. 13.

Crania Lælia, Hall; 24th Rept. State Cab., p. 220, pl. 7, fig. 16.

Shell small, discoid, or moderately convex on the upper valve; outline circular, or a little narrowed toward the cardinal border. Apex of the dorsal valve minute, not prominent, varying from sub-central to about one-third the length of the valve from the cardinal margin.

Surface of the dorsal valve marked by fine but sharply elevated, radiating striæ, which are sometimes tortuous, and frequently increased by implantation. Ventral valve and interior of the shell not observed.

This is a distinct and well-marked species, not readily mistaken for any other from rocks of this formation, although there are forms known in higher positions that resemble it somewhat. Its nearest described analogue is *C. crenistria*, Hall, from the Hamilton group of New York; but the striæ are sharper and the apex more appressed.

Formation and locality: In the Hudson River group, Oxford, Ohio. We have also seen specimens from Cincinnati.

GENUS ORTHIS, Dalman.

ORTHIS CLYTIE.

Plate 1., figs. 18, 19.

Orthis clytie, Hall; 14th Rept. State Cab., p. 90, 1861.

Orthis clytie, Hall; 15th Rept. State Cab., pl. 2, figs. 4 and 5.

Shell of medium size, semi-elliptical outline, with the cardinal angles rounded; valves plano-convex; hinge line less than the width of the

shell below. Ventral valve depressed, convex, most ventricose on the umbo; area narrow, longitudinally striated, extending a little more than two-thirds the width of the shell; divided in the center by a broadly triangular foramen, which is partly filled by the cardinal process of the opposite valve; beak very small. Dorsal valve flat in its normal condition, though generally concave from compression; area very narrow. Interior of the dorsal valve characterized by a strong mesial septum and highly elevated cardinal process, which is thin and not bifurcate; also by strong projecting crural processes and distinctly limited muscular impressions of medium size. Ventral valve marked by large cardinal muscular imprints, which are pointed anteriorly and widely divergent, the adductor muscle imprints being small and situated near the rostral portion of the valve; teeth not strong; muscular impressions strongly limited. Near the margin of both valves in the larger specimens there is a thickening of the valves, extending entirely around the shell, except near the central portion of the hinge line.

Surface of the valves marked by fine, closely arranged, radiating striæ, and by several strong concentric lines of growth, as well as by very fine concentric lines, which are undulated as they cross the radiating striæ.

The shell has much the form and appearance of *O. emacerata*, Hall, from the same geological formation, but is much larger and somewhat thinner in proportion to its size than that species, and the internal features are quite distinct. The ventral valve is not so distinctly carinate along the median line, although sometimes slightly so.

Formation and locality: In the shales of the Hudson River group, near Cincinnati, Ohio, but on the opposite side of the river. So far as we can ascertain, no specimens of the species have yet been found on the Ohio side.

ORTHIS ELLA.

Plate 1, fig. 20.

Orthis [?] *ella*, Hall; 13th Rept. State Cab., p. 121, 1860.

Orthis [?] *ella*, Hall; 15th Rept. State Cab., p. 158, Exp. pl. 2, fig. 6-8.

Orthis [?] *ella*, Hall; 24th Rept. State Cab., Exp. pl. 7, fig. 21.

Shell small, ovate; valves nearly equally convex; hinge line extremely short, being scarcely more and sometimes less than one-third the width of the shell, and scarcely affecting the contour of the cardinal margin, which slopes from the beak of the ventral to the lateral margins a little

above the middle of the valve. Dorsal valve gibbous, subcircular; the beak extending a little above the hinge line, and the area extremely short. Ventral valve broadly ovate, sloping from the beak; beak produced beyond the line of the opposite valve, and pointed, not incurved; area twice as long as high; foramen narrow and extending to the apex of the beak, and sometimes truncating the extremity.

Surface marked by from fifteen to twenty simple, abruptly rounded or subangular plications.

This small *Orthis* is so peculiar as not to be readily mistaken for any other known in our strata. The short hinge line and area, and the produced beak of the ventral valve, are characteristic features. In some specimens the area is obscure or undefined, and the shell has much the aspect of *Trematospira*. It is a rare species, and I have not seen more than twenty individuals, all of which preserve the characters given above, the variation being mainly in the number of striae; those with fewer striae are frequently more gibbous than the others. Length about one-third of an inch; the width a little more.

The above description is taken from the 13th Report of State Cabinet of New York, 1858 and 1859. Up to the present time there are no new facts in our possession in regard to the generic relations of this peculiar shell.

Formation and locality: In the calcareous shales of the Hudson River group, near Cincinnati, Ohio. From the collections of Mr. S. T. Carley and Mr. U. P. James.

ORTHIS JAMESI.

Plate 1, figs. 21, 22.

Orthis Jamesi, Hall; 14th Rept. State Cab., p. 89, 1861.

Shell small, transversely semi-elliptical; hinge line longer than the width of the shell below, with somewhat salient angles. Valves convex, the ventral much the deepest, with an elevated, almost pointed beak, and rather high, vertical, or slightly overhanging cardinal area, which is about four times as long as high, and divided in the center by a proportionally large fissure, once and a half as high as wide; the surface of the valve is regularly and evenly sloping from the small pointed beak to the edges of the shell in young specimens, and sometimes slightly carinate on the umbo, or becoming broadly and shallowly sinuate in front in larger individuals. Dorsal valve more evenly convex from the small incurved beak to the front, when not distorted by compression; often depressed just within the cardinal angles, giving slightly recurring car-

dinal extremities. Area narrow, foramen wide and open, the cardinal process being small and inclined inwards, does not fill the foramen, as is the case in many species.

Surface of the valves marked with from twenty-four to twenty-eight sharp, angular plications, commencing near the beak, and continuing simple for the distance of a quarter of an inch, beyond which point they frequently bifurcate, or are increased by implantation until they become fasciculate. This feature is only seen in the larger individuals, the young or smaller specimens having the plications simple, or marked only by a few added ones, the fasciculation not appearing until a more advanced stage of growth.

The shell somewhat resembles *O. plicatella*, but differs in the extended hinge line and in the inequality of the area of the two valves—that of the ventral being much larger than in that species, giving an entirely different form to the umbonal portion of the valve. It resembles much more closely young individuals of *O. tricenaria*, Conrad, but the plications on that species are always simple. Compared with *O. disparilis*, Conrad, from the Trenton limestones of Wisconsin, which appears to us to be only a young specimen of *O. tricenaria*, which species occurs abundantly in the same vicinity as the original *O. disparilis* came from; it differs in the greater convexity of the dorsal valve, and in the lower cardinal area of the ventral, as well as in the duplication of the plications.

Formation and locality: In the shales of the Hudson River group in the vicinity of Cincinnati, Ohio. We have seen specimens of what we believe to have been this species in collections under the name of *O. disparilis*.

LAMELLIBRANCHIATA.

GENUS PTERINEA, Goldf.

PTERINEA DEMISSA.

Plate 2, fig. 1.

Avicula demissa; Conr. Jour. Acad. Nat. Sci., Phil., Vol. VIII., p. 42, pl. 13, fig. 3.

Avicula demissa, Emmons; Geol. Rept. 2d Dist. N. Y., p. 404, fig. 2.

Avicula demissa, Hall; Pal. N. Y., Vol. I., p. 292, pl. 80, fig. 2.

Shell sub-rhomboidal in outline, with the basal margin rounded; hinge-line much longer than the body of the shell; anterior wing ex-

tended into a rather long, acute point, when perfect, forming nearly one-third of the length of the hinge, measured from the point of the beak; posterior wing large, rather obtusely pointed, and extending as far as the body of the shell below; body of the shell oblique, a line drawn from the beak to the center of the base forming an angle with the posterior hinge-line of about sixty-five or seventy degrees; posterior margin of the shell broadly and roundly, but not deeply, excavated between the posterior wing and the postero-basal extremity of the shell; basal margin rather sharply rounded; anterior margin obliquely sloping from the hinge-line, being nearly parallel with the body of the shell; very slightly excavated below the anterior alation. Left valve strongly convex when not compressed, prominent and rounded in the center, but flattened and slightly concave toward the alations; beak small, extending but little above the hinge-line; flattened or depressed convex on the umbo. Right valve concave, the concavity not exceeding one-half the convexity of the opposite valve, and usually somewhat shorter on the basal portion.

Surface of the convex valve marked by regular, concentric, lamellose lines, the edges of which are sharply elevated when well preserved, giving an exceedingly roughened character to the surface. In the degree of this latter feature, as also in the relative distance of the lines, there is considerable variation in different individuals. Surface of the concave valve distinctly lamellose, but the precise features have not been very clearly determined, as no very good specimens of this valve have been examined.

Formation and locality: Specimens of this species are not uncommon in the upper part of the beds of the Hudson River group, as seen at Cincinnati, Ohio, which do not appear to differ in any important feature from specimens found in the same formation in New York. The species is probably found at most localities of the formation, or will be on careful examination, as it is a form having a very extended geographical range.

GENUS AMBONYCHIA, Hall.

(Pal. N. Y., Vol. I., p. 163; 1847.)

AMBONYCHIA RADIATA.

Plate 2, fig. 2.

Ambonychia radiata, Hall; Pal. N. Y., Vol. I., p. 292, pl. 80, fig. 4.

Ambonychia radiata, Hall; 12th Rept. State Cab., p. 110.

Ambonychia radiata, Hall; Geol. Rept. Wis., p. 54.

Shell small to medium sized, varying in outline from sub-quadrangular, with a rounded base, to acutely ovate, according to the degree of obliquity

of the body of the shell to the direction of the hinge-line. Surface of the shell ventricose, and often sub-carinate on the umbones and toward the beaks, gradually and somewhat regularly sloping to the basal margin, becoming attenuate and compressed toward the postero-cardinal region, and abruptly truncate and even impressed on the anterior side. Beaks acutely pointed, strongly incurved, terminal, and projecting above the line of the hinge; posterior end at right angles to the hinge straight or rounded, or sometimes sloping obliquely backwards to the postero-basal margin; base sharply rounded. Anterior border of the valves excavated below the beaks, forming a rather large byssal opening, which is usually about half as wide as long when the valves are united.

Surface of the valves marked by strong, radiating ribs, which are simple throughout, strongest on the body of the shell, and becoming finer on the postero-cardinal region. On the upper portion of the shell the ribs are flattened on the top, and often grooved in the center, giving them a strongly duplicate character, but becoming smooth below, the spaces between as narrow, or much narrower, than the width of the rib. The ribs are crossed by fine, concentric, imbricating lines of growth, which undulate as they cross the elevation.

There seems to be considerable variation of form and surface characters among the specimens which appear to be properly referable to this species, so much so, that it is difficult to give the features which appear on different specimens in a single specific description, without appearing to go beyond the limits of reasonable specific distinction. The general form of the shell, in the first place, is so variable that one might select individuals, which, if taken alone, might serve as types of several distinct species; but in a collection of twenty or thirty specimens, taken promiscuously, will be found examples that will connect the whole into a series uniting the extremes of form. Among the specimens studied, we find examples where the hinge-line is at right angles to the posterior and anterior borders, these being parallel; in others the direction of the posterior margin will vary ten, fifteen, or even a greater number of degrees from a right angle with the hinge-line, being directed obliquely backwards; others, again, have the posterior and basal margins forming an almost regular curve from the posterior extremity of the hinge-line to the antero-basal portion of the shell. The base is sometimes broadly rounded, and, again, obliquely and acutely rounded, with the longest point much posterior to the middle of the shell. In the surface characters they also vary much in the form and number of the ribs, even among the more finely radiated forms. On some the ribs are flattened

on top, on others they are rounded, the spaces between being very narrow, or even wider than the ribs—the surface may be smooth or concentrically striated; yet among all these features there are none constant enough to constitute specific distinctions. Among specimens of *A. radiata* from the same rocks in New York, we find corresponding differences. The species *A. radiata* was founded upon the finely radiated forms, while the more coarsely ribbed form, which is sometimes quite angular on the umbonal ridge, was identified with *Pterinea carinata*, Goldf., which was originally described from a specimen of this character from New York, and which agrees, in most respects at least, with the western form known as *Ambonychia costata*, James.

Formation and locality: In the higher beds of the Hudson River group, at Waynesville, Ohio. The species occurs at other localities, and is often found in collections labeled as coming from Cincinnati, Ohio.

GENUS TELLINOMYA, Hall.

TELLINOMYA PECTUNCULOIDES.

Plate 1, fig. 24.

Tellinomya pectunculoides, Hall; Descr. New Species of Fossils from the Hudson River Group, etc., p. 4; 1871.

Tellinomya pectunculoides, Hall; 24th Rept. State Cab., p. 228, pl. 7, fig. 26.

The following is the description of this species, as given by Prof. Hall, as above cited:

“Shell small, sub-circular in outline, with the posterior end slightly prolonged below the middle, giving a little obliquity to the shell; posterior cardinal border sloping to the point of greatest extension; anterior and basal borders regularly rounded; beaks small; general surface of the valves depressed convex. Hinge plate strongly arcuate, more abruptly curving in the middle, occupied by ten or twelve teeth on each side of the center, those in the middle being nearly straight, becoming more and more bent and angular toward the extremities; muscular impressions large and distinct; pallial line strongly marked, situated considerably within the border of the valve. Surface characters of the valves not observed.”

Among the specimens examined from Cincinnati there is a slab of several inches square, covered with exfoliated specimens of this species, some of which preserve the shell sufficiently to show that the surface was

generally smooth and destitute of markings of any kind. The species is readily distinguished from the other forms associated with it by the more circular form, *T. levata* and *Lyrodesma Cincinnatiensis*, both being more pointed posteriorly and angular along the umbonal ridge.

Formation and locality: In the Hudson River group, at Cincinnati, Ohio. The original specimens were from the cabinet of Mr. C. B. Dyer.

TELLINOMYA LEVATA.

Plate 1, fig. 23.

Nucula levata, Hall; Pal. N. Y., Vol. I., p. 150, pl. 34, fig. 1.

Tellinomya levata, Hall; Descr. New Species of Fossils from the Hudson River Group, etc., 1871; Expl. of pl. 3, fig. 27.

Tellinomya levata, Hall; 24th Rept. State Cab.; Expl. of pl. 7, fig. 27.

The specimens of this species which we have observed from Ohio localities have usually been in a very bad state of preservation, seldom retaining the general features of the shell sufficiently perfect for identification. The species found in New York is sub-rhomboidal in outline, broadly sub-ovate, obtusely pointed at the posterior end, and rounded anteriorly, with ventricose valves and proportionally large, pointed, moderately incurved beaks. The specimens are usually about half an inch long, and a little less in height. The individual figured shows only the hinge plate and a portion of the margin of the shell, the interior being filled with rocky material. The species may be readily distinguished from other similar forms associated with it by the curvature of the hinge plate beneath and posterior to the beaks.

Formation and locality: On the surface of the limestone slabs from the Hudson River group, at Cincinnati, Ohio, and also occasionally flattened individuals from the softer portions of the group in the same vicinity.

GENUS LYRODESMA, Conrad.

LYRODESMA CINCINNATIENSIS.

Plate 1, fig. 25.

Lyrodesma Cincinnatiensis, Hall; Descr. New Species of Fossils from the Hudson River Group, etc., 1871, p. 4.

Lyrodesma Cincinnatiensis, Hall; 24th Rept. State Cab., p. 227, pl. 7, fig. 28.

"Shell small, sub-rhomboidal in outline, and obtusely pointed at the postero-basal angle; valves moderately convex, with a sub-angular um-

bonal ridge and narrow cardinal slope; anterior end rounded and passing into the broadly rounded basal line; posterior end oblique, pointed below; hinge line short; beak very small. Hinge plate occupied by six angular, crenulated, radiating teeth, which diverge from beneath the beak, and are strongly arched upwards between their origin and extremities; crenulations minute, but very distinct; muscular impressions and pallial line not observed."

The specimens of this species that have been observed lay imbedded on the surface of limestone blocks, and present the inner side of the shell to view, so that the exterior features of the shell have not been seen, consequently a full description of the species can not be given. The species differs in the general form from *L. postriata*, and also from *L. plana*, found in the same geological position in New York, in the more equal length and breadth of the valves. The form is somewhat similar to that of *Tellinomya levata*, associated with it, but the angularity of the umbonal ridge will serve to distinguish it externally, while the concavity of the posterior hinge line, as well as the form of the teeth, will readily distinguish it internally.

Formation and locality: In the limestones of the Hudson River group, near Cincinnati, Ohio. The originals were from the collection of C. B. Dyer.

GENUS MODIOLOPSIS, Hall.

(Pal. N. Y., Vol. I., p. 157.)

MODIOLOPSIS MODIOLARIS.

Plate 2, fig. 17.

Pterinea modiolaris, Con.; Ann. Rept. Geol. Surv. N. Y., 1838, p. 118, and 1839, p. 63.

Cypricardites modiolaris, Con.; Ann. Rept. Geol. Surv. N. Y., 1841, p. 52.

Cypricardites ovata, Con.; Ann. Rept. Geol. Sur. N. Y., 1841, p. 52.

Cypricardites ovata, Emmons; Geol. Rept. 3d Dist. N. Y., p. 405, fig. 2, 1842.

Cypricardites angustifrons, Emmons; Geol. Rept. 3d Dist. N. Y., p. 405, fig. 1.

Modiolopsis modiolaris, Hall; Pal. N. Y., Vol. I., p. 294, pl. 81, fig. 1, and pl. 82, fig. 1.

Modiolopsis modiolaris, Hall; Foster and Whitney, Lake Sup., p. 214, pl. 31, fig. 2a.

Shells of this species are not uncommon among collections of Lamelli-branchiates from the vicinity of Cincinnati. They are, however, usually in the conditions of casts of the interior, and present only the internal characters, beyond the general outline and form of the shell. Occasion-

ally, however, examples are obtained preserving the surface markings and other specific features. The form of the shell is elongate ovate, widest within the posterior third of the length; hinge line distinctly arcuate throughout, and strongly bent beneath the beak, the shell being contracted in width at this point, giving a narrow, sharply rounded anterior end, which is longest below the line of the middle of the shell. Basal line sinuate a little anterior to the middle, corresponding to a broad, shallow, and undefined sulcus which crosses the valves; posterior end strongly rounded; shorter above the central line than below, and gradually rounding into the posterior cardinal border. General surface depressed convex; beaks small, compressed, and but slightly elevated above the limits of the hinge plate. This latter feature is considerably changed in many of the casts by the removal of the substance of the shell from between the beaks, leaving a much greater depth below the beaks than is really the case with the shell itself, giving them the appearance of considerable elevation.

Surface of the valves moderately convex; most flattened toward the anterior end; the middle of the valve marked by a broad, undefined sulcus; the whole marked by fine, irregular striae, and a few stronger lines indicating stages of growth. Anterior muscular scar large, rather strongly marked; posterior scar large, and very faintly marked.

This species differs from *M. pholadiformis*, Hall, in being destitute of the diverging plications which characterize that species; and from *M. concentrica*, herein described, by its greater size, and by the absence of the regular, concentric plications on the posterior slope, as seen on that species.

The specimens occur usually much compressed, so that the valves show but little convexity; but some of those obtained have been compressed vertically, producing an unnatural degree of convexity, and considerable angularity along the umbonal ridge and on the central parts of the shell—at the same time shortening the vertical height of the specimens.

Formation and locality: In the shales of the Hudson River group, near Cincinnati, and Waynesville, Ohio.

MODIOLOPSIS PHOLADIFORMIS.

Plate 2, fig. 16.

Modiolopsis pholadiformis, Hall; Fost. and Whit., Lake Sup., p. 213, pl. 30, fig. 1, and pl. 31, fig. 1.

Shell of medium size or larger, sub-ovate in outline, widest posteriorly; the length usually about twice as great as the breadth. Valves depressed convex, but usually flattened by compression; umbonal ridge slight, sub-angular in the upper part, becoming almost obsolete behind; anterior portion having a slight sulcus crossing the valves from the beak, and reaching the base at or within the anterior third of the length. Hinge line arcuate; anterior end contracted below the beaks, slightly prolonged, and narrowly rounded in the lower part; basal line contracted at about a third of its length from the anterior end, corresponding with the sulcus crossing the shell, and strongly curved upwards toward the posterior extremity; posterior margin obliquely truncate; longest at the postero-basal angle, and rounded toward the extremity of the hinge line. Beaks small, compressed, slightly angular, and projecting but little above the hinge.

Surface of the valves marked with numerous irregular, concentric lines of growth, strongest on the anterior end; and also by low, rounded, somewhat irregular, and occasionally bifurcating plications, which diverge from the umbonal ridge, curving gently backwards in their course toward the basal line, and more strongly to the cardinal margin. Anterior to the sulcus of the valves these diverging plications have not been noticed, and it is probable that they do not occur on this part of the shell.

The species has about the same general form and outline as that of *M. modiolaris*, but differs very materially in the existence of these diverging plications of the surface, and also from any other shell found associated with it.

Formation and locality: In the soft shales of the upper part of the Hudson River group, near Waynesville, Ohio. We have not seen specimens of this species from any other locality in Ohio, but it is probable that they may occur in most localities of the upper beds of the formation, as it appears to have a somewhat extended geographical range; the original specimens of the species being from the Little Bay de Noquet, at the upper end of Green Bay, Lake Michigan.

MODIOLOPSIS TRUNCATUS.

Plate 2, fig. 13.

Modiolopsis truncatus, Hall; Pal. N. Y., Vol. I., p. 296, pl. 81, fig. 3.Comp. *Anodontopsis unionoides*, Meek; Pal. Ohio, Vol. I., p. 141, pl. 12, fig. 2.

Shell below the medium size; shortly ovate in outline, the widest part being about one-third of the entire length from the posterior end. Valves compressed, or depressed convex, most prominent near the center. Beaks small and closely compressed, scarcely projecting beyond the line of the hinge. Anterior margin rather shortly rounded, the extremity extending but little beyond the beaks; basal margin gently and regularly curving; posterior end more broadly rounded than the anterior, and most abruptly at the postero-basal portion; above, it slopes more gradually backwards to the extremity of the hinge line, with which it unites without forming any perceptible angle.

Surface of the valves marked by irregular, rather strong, concentric lines of growth.

The internal casts—the condition in which the species is usually found in the softer parts of the formation—show a large, elongate posterior muscular scar, situated a little within the postero-cardinal margin, and parallel with it; also a smaller lunate anterior scar, and an entire pallial line. The hinge plate would seem to have been of considerable width, but its features have not been observed in specimens from Ohio. Those from the sandy shales of the formation in New York show it to have been a true *Modiolopsis*.

Formation and locality: The species appears to have been not uncommon in the soft shales of the Hudson River group, in the vicinity of Cincinnati, Ohio, as specimens have been derived from several sources with this label. Examples have also been received from Prof. Edward Orton, from the more compact layers at the base of the formation, at Frankfort, Kentucky. We are also strongly inclined to believe that the specimen figured in Vol. I., Pal. Ohio, pl. 12, fig. 2, under the name *Anodontopsis unionoides*, will prove to belong to this species.

MODIOLOPSIS CONCENTRICA (n. sp.).

Plate 2, fig. 18.

Shell of medium size; elongate ovate in outline; broadest near the posterior end, and contracted in front of the beaks. Hinge line arcuate, gradually declining toward the extremity and rounding into the posterior margin, which is more sharply rounded below than above the mid-

dle; basal line gently curved, becoming a little sinuate at or about the anterior third of its length; anterior end narrowly rounded. Beaks small, and compressed on the back, projecting but little above the hinge. Surface of the valves moderately convex when not distorted by pressure; most prominent about the umbonal ridge, which is low, and broadly rounded; not forming a conspicuous feature of the valve. A very slight and rather undefined mesial sulcus crosses the valves from the beak to the sinus of the basal margin.

Surface of the shell marked on the cardinal slope and posterior end by regular, even, concentric furrows, from three to four of which occupy the space of an eighth of inch in their strongest parts. These furrows are most distinctly marked near the cardinal margin, and become obsolete in crossing the umbonal ridge; existing on the basal portions and anterior end only as fine, irregular, concentric striæ of growth. Anterior muscular impression strongly defined and proportionally large; forming a rather distinct, sub-circular or reniform protuberance on the anterior end of the casts; posterior impression not observed; pallial line often distinct on the anterior half; partly composed of detached transverse pustules.

The specimens of this shell observed in collections have generally been found among and considered as identical with those of *Modiolopsis modiolaris*, but it is always of much smaller size, being generally not more than two-thirds as long when fully grown as the ordinary sized individuals of that species, and although the general form is very similar, the concentric markings of the cardinal slope and posterior end readily distinguish them. These markings are of such a nature that they are usually preserved on all specimens retaining any specific markings. The specimens are frequently much distorted by compression, and when the pressure has been vertical, or in the direction of the plane of the shell, the convexity is considerably increased, often causing them to appear nearly cylindrical.

The species resembles very closely *Modiomorpha concentrica* of the Hamilton formations of New York (*Modiola concentrica* of authors) in its general appearance and surface markings, so much so, that it might readily be mistaken for that shell; but the concentric, undulating striæ becoming obsolete on the umbonal and anterior portions of the shell, will serve, we think, as an unfailing means of distinguishing them—the striæ on that species continuing over all parts.

Formation and locality: In the softer layers of the Hudson River group, near Waynesville, Ohio. Received from Jesse Van Duser, Esq., of that place. We have seen specimens labeled Cincinnati, Ohio, and perhaps it may also occur at that locality.

MODIOLOPSIS CINCINNATIENSIS (n. sp.).

Plate 2, figs. 14, 15.

Shell of medium size or smaller; elongate ovate, or narrowly sub-elliptical in outline; widest posteriorly, and abruptly contracted in front of the beaks; hinge line slightly arcuate, and a little more than half as long as the shell posterior to the beaks; posterior margin obliquely sloping, with a slight convexity, from the extremity of the hinge line to the postero-basal angle, which is the point of greatest length of the shell. Basal line gently curving throughout its length in most cases, but in some examples becoming slightly sinuate opposite or a little posterior to the beaks. Anterior end narrow, not very extended, and sharply rounded. Beaks small, appressed; projecting but little above the hinge line, and situated just within the anterior third of the length of the shell. General surface of the shell moderately convex; most prominent along the posterior umbonal ridge, which is sharply rounded or obscurely angular; umbonal slope abrupt and slightly convex. An obscure, shallow mesial depression extends across the valves from the beaks, reaching the basal line just behind the anterior third of the length.

Surface marked by numerous, irregular, concentric lines of growth, which are often strongly marked, but without any definite arrangement; a little stronger on the anterior portion of the shell than elsewhere. The substance of the shell is thin, and the surface, when perfect, quite polished.

This species bears considerable resemblance to the larger specimens of the form identified with and figured as *M. anodontoïdes*, Conr., in Palæontology of New York, Vol. I, p. 298, pl. 82, fig. 3*b*, but differs in the greater breadth posteriorly, and in being much more contracted in width in front of the beaks. From the other forms given on the same plate as the same species it differs more strongly, and can not be readily confounded with them. The specimen represented by fig. 3*a* of the same plate, which is the original of the species used by Mr. Conrad for description, and that which must be considered as possessing the true specific characters, is much more angular along the umbonal ridge; the hinge line is proportionally longer, and the anterior end of the shell shorter and broader than in the species under consideration.

Formation and locality: In limestone of the Hudson River group, near the base of the formation, at Cincinnati, Ohio.

GENUS SEDGWICKIA, McCoy.

SEDGWICKIA? DIVARICATA (n. sp.).

Plate 2, fig. 3.

Shell small, transversely elongate ovate, widest posterior to the middle; length of the shell about twice the width; beaks pointed, prominent, and projecting above the hinge line; flattened on the back and sharply angular on the ridge; valves somewhat compressed; hinge line slightly arcuate, and extending to within a short distance of the greatest length of the shell; posterior extremity broadly and somewhat regularly rounded; basal margin gently and evenly convex to within a short distance of the anterior end, where it is more abruptly curved upward to the anterior extremity, which latter is a little above the center of the shell and sharply angular, the upper side sloping rapidly from between the beaks to the point of greatest extension. Valves distinctly angular along the umbonal ridge, which extends in nearly a straight line from the beak to the postero-basal margin; above the ridge the cardinal slope is wide, gently convex in the higher portions, but becoming compressed toward the postero-cardinal region. Anterior to and below the umbonal ridge the general surface of the valve is flattened, or very depressed convex, with a gradual slope from the crest of the ridge to the border of the shell.

The surface of the valves is marked by two sets of ridges, the first set forming concentric undulations parallel to the lines of growth, and are, for the size of the shell, proportionally strong; posterior to and above the umbonal ridge they are not so distinctly marked. The second set exist in the form of strong, rounded plications, diverging from the line of the umbonal ridge toward the base of the shell below, and to the cardinal margin above, each of them curving very gently toward the anterior end in their course to the border of the valve. These plications are mostly simple, but a few of them appear to bifurcate.

This feature of diverging plications marking the surface of Lamellibranchiate shells of the Silurian formation is an exceedingly rare one; and it is somewhat remarkable that two species should occur in the same formation, and in the same vicinity, having this form of surface ornamentation, *Modiolopsis photadiformis*, Hall, being the other species. They are, so far as we are aware, the only American forms from rocks of this age having this style of marking.

There may be some doubt as to the true generic relations of this species, as the specimen does not present any of the internal features. It can not with propriety be placed under *Modiolopsis* or *Orthodesma*, as the projecting beaks is a feature not likely to pertain in a species of either of those genera; we therefore place it provisionally under the genus *Sedgwickia*, from a resemblance in external form to some of the species referred to that genus by its author, although we are in great doubt as to the precise characters of that genus, from the heterogeneous material referred to it.

Formation and locality: In the shales of the Hudson River group, at Blanchester, Ohio. The specimen described and illustrated is the property of U. P. James, Esq., of Cincinnati, and is, we believe, the only individual yet discovered.

GENUS CUNEAMYA (new gen.).

Thin, fragile, bivalve shells, with ventricose valves, and strong, prominent, incurved beaks. Cardinal line straight, or gently curved. Hinge edentulous. Valves united by an external ligament of greater or less extent, posterior to which the margins of the valves overlap each other to the extent of the cardinal line. Margins of the valves inflected along the cardinal border, forming a narrow escutcheon posterior to the beaks, and anteriorly a well-defined lunule is situated below the beaks. Adductor muscles, at least two, are anterior and posterior. Pallial line simple. Type, *Cuneamya Miamiensis*.

The above genus is proposed for the reception of a group of Silurian Lamellibranchiate shells, which have been variously referred to *Leptodomus*, *Grammysia*, *Sedgwickia*, etc., but which do not appear to us to possess the true features of any of those groups; and although the entire features of the shells under consideration have not been fully and positively determined, the want of a term by which to designate them is so strongly felt in their description that we have thought it advisable to propose a group for their reception, rather than to refer them to one with which we are perfectly satisfied they have no affinity. Although Prof. McCoy has himself described similar forms as *Leptodomus*, yet the type of that genus is of such an entirely different nature that we do not hesitate to pronounce these as belonging to an entirely different class of shells. From *Grammysia* they differ considerably in their external characters, but more decidedly in the absence of the strong, tooth-like fold of the hinge, which the shells of that genus are now known to possess.

With *Sedgwickia* we believe them to have little or no affinity; still, from the very heterogeneous nature of the material referred to that genus, we are somewhat at a loss to know of what the group consists, until the characters of the types can be ascertained.

CUNEAMYA MIAMIENSIS (n. sp.).

Plate 2, figs. 9, 10.

Shell small, cuneiformly ovate in outline, largest at the anterior end, tapering, and somewhat pointed posteriorly. Valves very ventricose in the anterior part and on the umbonal region, approaching gibbosity; beaks proportionally large, strongly enrolled, projecting prominently above the hinge line, and nearly or quite terminal, varying in this latter feature slightly in different individuals; cardinal line very little curved, extending more than half the length of the shell posterior to the beaks; escutcheon distinct, but not strongly marked; lunule very distinct, moderately large, and deeply impressed, the margins being somewhat angular; anterior end of the shell inflated, the border rapidly sloping backwards from the lower extremity of the lunule to the basal line, into which it gradually fades; basal line moderately arcuate, with a broad, shallow sinus about midway of its length, corresponding to the very shallow depression of the surface of the valve; posterior end acutely rounded, sloping rapidly above from the extremity of the hinge line to near the point of greatest length; posterior umbonal ridge very prominent and rounded on the anterior two-thirds of the shell, gradually becoming less prominent posteriorly; cardinal slope moderately concave; anterior umbonal region very full and abruptly rounded, and declining to the anterior margin of the valve, giving to this end of the shell a somewhat truncated aspect; central portion of the valves slightly depressed, forming a broad, shallow, and undefined sulcus, extending from the beaks, and gradually widening to form the broad, shallow sinus of the basal line.

Surface of the shell marked by numerous, rather fine, or proportionally small, even, concentric plicæ or ridges, extending from the margin of the lunule to beyond the posterior umbonal ridge, becoming obsolete on the cardinal slope. The number and size of these concentric furrows and ridges vary considerably in different individuals of the species.

Specimens of this species were received from persons in Ohio, with the understanding that it had been described by Mr. Meek as *Grammysia*

neglecta. Not having then seen his figures, and the species having been described from very imperfect material, we were not able to determine fully the specific relations. On strictly comparing it, however, with his description and figure, as given in the first volume Palæontology of Ohio, pl. 12, fig. 8, it proves to be a very distinct species. Mr. Meek describes his species as "about one-third longer than high, rather distinctly compressed, most convex and most elevated in the central and umbonal region"—also as having the basal line forming a "nearly semi-oval curve, its most prominent part being near the middle"—while the species under consideration is about twice as long as high, not at all compressed, but, on the contrary, extremely ventricose, except near the posterior extremity, with the central portion not so prominent as the umbonal ridge, and with the basal line broadly sinuate, instead of forming a semi-oval curve, the depression in the basal line being just where that one is the most prominent. Several specimens of this species examined preserve these features well marked. Another species, associated with this one in the same position and locality, has many more characters agreeing with Mr. Meek's description and figure, a small individual of which is represented on the plate, under the name adopted by him, for comparison. Among the collections of Prof. Edward Orton there is a specimen nearly twice the size of the one figured.

Formation and locality: In the shales of the Hudson River group, near Waynesville, Ohio.

CUNEAMYA SCAPHA (n. sp.).

Plate 2, fig. 12.

Shell of medium size, transversely elongate ovate, largest at the anterior end, with prominent, incurved, nearly terminal beaks; cardinal and basal margins parallel, or nearly so; posterior end broad, obliquely truncate, and rounded from the extremity of the hinge line to the postero-basal angle; anterior end very slightly prolonged beyond the beaks, the upper margins inflected, forming a rather large sized lunule, below which the border slopes abruptly backwards to the basal line, forming a somewhat obtuse or undefined angle at their junction; basal line gibbous at the anterior and posterior third of its length, flattened or somewhat sinuate in the middle. Surface of the valves convex for the anterior two-thirds of the length and to the crest of the umbonal ridge, beyond which it slopes abruptly to the postero-cardinal margin, being

almost concave between the two points, and giving a rather abrupt or sub-angular umbonal ridge, which curves in its course from the beaks to the postero-basal angle. The middle of the shell is marked by a broad, usually undefined, but sometimes distinct, oblique, mesial sulcus, extending from the beaks to the basal margin, and occupying almost the entire space between the umbonal ridge and the anterior prominence. Cardinal slope broad, marked by a faint secondary ridge extending from behind the beaks to the middle of the postero-cardinal body. Surface of the shell marked by fine, somewhat even, concentric lines of growth, but without evidence of concentric ridges or plicæ.

This species differs from *C. Miamiensis* in the much less ventricose valves, less prominent beaks, and umbonal region, in the sub-parallel cardinal and basal margins, and in the absence of concentric ridges. From *Sedgwickia (Grammysia) neglecta*, Meek, it differs in the less prominent beaks, in the straight or broadly sinuate basal margin, in the less convexity of the central region of the valves, and in the absence of the concentric undulations of the surface.

Formation and locality: In the soft shales of the Hudson River group, near Waynesville, Ohio.

GENUS ORTHODESMA (new gen.).

More or less elongate, bivalve shells, having the hinge line straight and generally extended posterior to the beaks, but contracted or bent beneath or anterior to them; hinge plate apparently edentulous; valves united by an external ligament extending to a greater or less distance along the posterior cardinal margin. Posterior muscular scar elongate ovate, anterior scar smaller, both faintly marked; pallial line simple. Shells thin, marked externally with irregular concentric plicæ. Type, *Orthodesma recta*.

The shells for which the above generic name is proposed are thin and generally compressed. They have usually been referred to the genus *Orthonota*, Conr., or to *Modiolopsis*, Hall, but do not possess the generic features of either. From *Orthonota* they differ in having the hinge line bent or contracted beneath or just anterior to the beaks, instead of being continued in a straight line to the anterior extremity of the shell, as in *Orthonota undulata*, the species upon which Mr. Conrad founded the genus. From *Modiolopsis* they differ in the absence of hinge teeth, so far

as can be ascertained from several specimens and species examined, this part of the shell being very similar in character to that of the genus *Anodonta*.

All the species yet fully determined as belonging to the genus are from the Hudson River group, but we are of opinion that several forms found in the Clinton group of New York will prove to have the same generic features.

ORTHODESMA RECTA (n. sp.).

Plate 2, figs. 7, 8.

Shell elongate, solen-like in outline, two and a half to three times as long as wide, the cardinal and basal lines posterior to the beaks straight and parallel; anterior end abruptly contracted beneath the beaks to one-half the width of the body of the shell, somewhat extended and abruptly rounded at the extremity; posterior end as broad as the body of the shell, obliquely rounded, longest at the postero-basal angle, and gently sloping backwards to the extremity of the hinge line; beaks small and compressed; surface of the valves between the umbonal ridge and the anterior contracted portion depressed, forming a broad, shallow, and undefined sulcus, strongest toward the beaks, and becoming obsolete or lost in the general flattening of the shell before reaching the basal line, in which it scarcely produces any perceptible feature.

The surface of the valves is marked by irregular, concentric lines of growth, and by several stronger undulations, which become somewhat regular on the posterior slope for a short distance below the hinge line. There are also appearances of one or two obscure secondary ridges on the cardinal slope between the umbonal ridge and the cardinal margin, extending from near the beak to the posterior end of the shell. This latter feature is extremely faint, and may be often not observable.

The species is not readily confounded with any other found in the same geological position, except, perhaps, *O. curvata*, from which it may be distinguished by the contraction of the basal line and the greater posterior breadth of the shell in that species. It somewhat resembles *Orthodesma parallela*=*Orthonota parallela*, Hall, Pal. N. Y., Vol. I., p. 299, pl. 82, fig. 7, from the Hudson River group of New York, but differs in the greater contraction of the anterior end, the broader beaks, the broad, undefined depression of the median portion of the valves, and in the form of the posterior end of the shell, which in that species is rounded,

while in this one it is obliquely truncate. The surface characters also differ very materially in the two forms, that one having fine, even, regular, concentric lines over the anterior two-thirds of the valves.

Formation and locality: In the soft shales of the upper part of the Hudson River group, near Waynesville, Ohio. The specimen figured was obtained, with several others of different species, from Mr. Jesse Van Duser, of Waynesville, Ohio.

ORTHODESMA CURVATA (n. sp.).

Plate 2, fig. 6.

Shell transversely elongate and narrow, the length equal to twice and a half or three times as great as the greatest width; cardinal and basal margins sub-parallel, or very gradually diverging posteriorly to near the posterior end; cardinal line straight for one-third of the length of the shell posterior to the beaks, beyond which point it gradually curves downward to near the extremity, which is abruptly rounded, the longest portion being below the center; basal line gently concave for two thirds of its length, but gradually rounding upwards at each end; anterior end long, equal to about one-fifth, and in some individuals nearly one-fourth, of the entire length of the shell, suddenly contracted beneath the beaks to about one-third the width of the shell across the beaks; beaks short and broad, slightly enrolled, and obliquely sloping anteriorly; body of the shell moderately convex, with a faint, scarcely perceptible umbonal ridge, anterior to which there is a broad, shallow depression crossing the valves from the beaks to the basal line, occupying fully one-third of its length. Anterior muscular scar strongly marked and of medium size, situated very near to the anterior extremity; posterior scar not observed.

Surface of the valves marked by numerous concentric wrinkles, often strongly marked on the cardinal slope near the cardinal border, and by finer, irregular lines of growth.

The species bears considerable resemblance to *Modiolopsis nasuta*, Hall, from the Hudson River group of New York, and was, at first sight, thought to be identical with that species; but, on comparison with authentic specimens, it is found to have a much greater length posteriorly in proportion to the length of the anterior end, that one being about twice as long posteriorly as anteriorly, while this species is from three to four times as long. The length of the shell is also greater in proportion to the height from the basal to the cardinal margin.

Formation and locality: In the soft shales of the Hudson River group, near Waynesville, Ohio. Collections of Columbia College and of Prof. Edward Orton.

ORTHODESMA PARALLELA.

Orthonota parallela, Hall; Pal. N. Y., Vol. I., p. 399, pl. 82, figs. 7a and d.

The specimen represented by the figures 7a and d, *loc. cit.*, was obtained many years ago among fossils collected at Cincinnati, Ohio. It is an internal cast in a calcareous sandstone, and was referred to the above species from its similarity of form in the absence of external characters. On strict comparison with the New York specimens, one of which is represented by fig. 7c of the same plate, and another by fig. 7b, there are certain features that would seem to indicate it as belonging to quite a distinct species. The umbonal ridge is strongly marked and sub-angular, and the flattening of the sides of the shell, as well as the greater gibbosity of the valves, could never have existed on a shell specifically identical with that represented by fig. 7c. From the character of the rock composing the cast, and from the uncertainty of its exact locality, there may possibly be some doubt of its geological position; and for these reasons we prefer to leave it without specific name until other and authentic specimens shall be obtained.

ORTHODESMA CONTRACTA.

Plate 2, figs. 4, 5.

Orthonota contracta, Hall; Pal. N. Y., Vol. I., p. 300, pl. 82, fig. 8.

Shell small, elongate trapezoidal, length twice and a half to three times the width; cardinal and basal margins sub-parallel; hinge line exceeding half the length of the shell, straight posterior to the beaks; posterior end obliquely truncate, scarcely rounded on the margin; basal line straight or gently sinuate near the middle; anterior end contracted beneath the beaks to a little more than half the width of the body of the shell, and extended anteriorly to a distance equal to its width; extremity sharply rounded; beaks small, incurved, flattened on the umbones, and projecting a little above the line of the hinge; umbonal ridge prominent and sub-angular; cardinal slope flattened, or slightly concave.

Surface of the shell marked by fine, irregular, concentric lines, and by stronger, distant undulations, or varices, marking stages of growth, and also on the cardinal slope by several strong, equi-distant, oblique plications parallel with the posterior extremity of the shell, extending from

the cardinal margin to the crest of the umbonal ridge, where they become obsolete.

This species is readily distinguished from any of the other forms associated with it, by the strong, distant, and oblique plications of the cardinal slope, which is a marked feature.

The original figures of this species, given in Volume I., Palæontology of New York, as above cited, have been copied by several European authors, and referred to as an example of the genus *Orthonota*, Conrad. It is scarcely necessary, however, to say that it differs very materially from the true type of that genus, *Orthonota undulata*, Conr., which has a hinge line, perfectly straight, extending beneath the beaks and reaching to the extremity of the anterior end of the shell. The undulations of that shell, as well as the secondary ridges of the cardinal slope, differ very materially from the short, oblique plicæ marking this species. The genus *Orthonota* consists of the first or earliest solen-like shells of which we have any knowledge, and the earliest form in which there is the slightest chance of finding a *pallial sinus*—the pallial line in all the forms which we know in rocks of earlier date being without sinus—and we are not certain in this one or even in any Devonian genus, of a truly sinuate pallial line.

CEPHALOPODA.

GENUS ORTHOCERAS, Breyn.

ORTHOCERAS DUSERI (n. sp.).

Plate 3, figs. 2-4.

Shell of medium size, rather rapidly and gradually enlarging from below upwards, the diameter increasing to twice the size in the space of four and a half inches. Transverse section circular; length of the outer chamber not determined. Septa moderately concave, and closely arranged, but gradually increasing in distance with the increased size of the shell—six chambers occupying the space of one inch where the diameter of the shell is one and a half inches at the upper one of those measured; nearer the joint there are ten to twelve in the same distance where the diameter is only three-fourths of an inch. Siphuncle eccentric situated a little nearer to the center than to the margin; very small where it passes through the septa, but expanding within the chambers

to about four times its diameter at the other point, and forming a flattened bead-like body within each chamber.

Surface of the shell apparently smooth, except that the edges of the septa are raised above the general level, in the form of narrow rings. This feature may possibly be due, in part at least, to an expansion of the septa during the process of petrification, but it would scarcely seem to be the case, as the feature is too regular, and only shows where the external shell is wholly or partly preserved. The rings are often some little wider on the surface than the thickness of the septa. Where the surface is most perfectly preserved there is also a finely reticulate or net-like character, dividing the surface into small rhombic figures of microscopic dimensions, having their longest diameters corresponding to the length of the shell, and presenting a surface similar to that frequently produced by the attachment of bryozoans; but the regularity is so great that this can not have been the origin of the feature; neither have the rhombs any thing like a radial structure or direction in any part, as would have been the case if they were the result of the growth of a bryozoan. Along one side of the shell and directly opposite to the position of the siphuncle, there is a narrow, raised, longitudinal line, extending the entire length of the tube, but slightly interrupted just above each one of the annular rings.

The species resembles somewhat the *O. crebrisseptum*, Hall (Palæontology of New York, Vol. I., p. 313, pl. 87), but increases much more rapidly in size, and does not possess the longitudinal markings of that species. In the rapid expansion of the tube it corresponds nearly with *O. Sieboldi*, Bill., from the island of Anticosti; but the septa are much more numerous, that one having seventeen in the space of seven inches, while this one has the same number in the space of two and a half inches.

Formation and locality: In the shales of the Hudson River group, near Waynesville, Ohio. The specific name is given in honor of Jesse Van Duser, Esq., of that place, who furnished the specimen, and several others, described and figured, from the same locality.

ORTHOCERAS CARLEYI (n. sp.).

Plate 4, fig. 19.

Among the fossils received for examination from the Hudson River formation there is a very interesting specimen of *Orthoceratite*, which does not appear to belong to any described species, but is in such a state of preservation as to present but few distinguishing features. Still, the

conditions under which it presents itself are of such a nature as to make it one of considerable interest. The specimen consists of an inner septate tube of a little more than five inches in length, with a diameter at the lower end of about three-eighths of an inch, by about seven-eighths at the upper end, giving an increase of half an inch in the length of five inches, or of one-tenth of the length. This tube is surrounded by two others, one within the other; each of the three being separated by a space of about an eighth of an inch on either side, giving to each about the same degree of expansion. The spaces between the tubes are filled with sedimentary matter; that between the inner and middle tube being composed chiefly of finely comminuted organic remains, while that between the two outer tubes is composed of fine silt chiefly, and in some places with crystalline matter. The septa of the inner tube are closely arranged, eight of the spaces measuring one inch where the upper end of the space measured is seven-eighths of an inch in diameter, those below being a little closer. These are all either empty spaces, or filled only by crystalline matter. There is not the least evidence of septa or partitions of any kind across the spaces between the several tubes. The specimen lies imbedded in the rock, and weathered away to near the center of its diameter, but the section at the end shows that the inner tubes rest upon, or nearly upon, the inner surfaces of the surrounding ones, as though they had settled to this position after they had been imbedded in the sediment. These conditions would seem to indicate that there had been no very intimate connection between the several tubes, and that the spaces between the outer ones and the inner septate portion had been open to the access of foreign matter, while the inner septate portion had been closed, or that the outer tubes had been independent of each other, and of the inner ones, and had only drifted into each other by accident. If this has really been the case, these outer tubes must be only the terminal chambers, or chambers of habitation, and must have been of unusual length, as the degree of tapering would carry the middle tube to within a few inches, if perfect at the lower end, of the point of a specimen nearly or quite fifteen inches in length. The probability, however, is that they are only fragments of outer chambers that have drifted upon the inner ones by accident.

At first sight the specimen might be taken for a beautiful example of the genus *Endoceras*; but true examples of this genus are septate in the outer tubes, while the inner ones are free from septa. The reverse is, however, the case in the example before us.

Formation and locality: The specimen occurs in a fragment of limestone composed principally of comminuted organic remains, and from its character appears to have

been part of a drifted or loose piece. From the upper part of the Hudson River group, at Fayetteville, Brown county, Ohio. Collection of S. T. Carley, Esq., formerly of Cincinnati.

ORTHOCERAS TURBIDUM (n. sp.).

Plate 3, fig. 1.

Shell of moderate size and very gradually tapering; septa not very closely arranged—four, or a little less than four, of them occupying the space of an inch where the diameter of the shell is one and a quarter inches; on the specimen used for description, which has been somewhat flattened accidentally, giving a slightly increased width. Septa moderately concave; siphuncle unknown.

Surface marked by low, rounded, longitudinal ridges, about four and a half to five of which occur in the space of half an inch.

The fragment from which the description is taken, and which is, so far, the only specimen known, is somewhat compressed, so that the spaces representing the chambers are slightly displaced and otherwise distorted, so that the entire characters of the species can not be determined. But the surface features of the shell are so distinctive and so unlike any others from this horizon that it can not be readily confounded with them.

Formation and locality: In the shales of the Hudson River group, at Cincinnati. Collection of U. P. James, Esq.

GENUS GOMPHOCERAS, Sowerby,

GOMPHOCERAS EOS (n. sp.).

Plate 3, fig. 5.

Shell rather above the medium size, ovoid in form, somewhat tapering from below upward to the middle of the outer chamber, and as rapidly contracting above. Outer chamber apparently forming fully one-third of the entire length of the shell, judging from the form of that portion preserved in the specimen, the whole being of an elongate ovate form. Septa deeply concave, and arranged at about one-fifth of an inch distant from each other. Siphuncle not satisfactorily determined. Surface of shell and form of aperture unknown.

The specimen from which the description is taken is quite imperfect

and flattened, measuring about four and a half inches in length, by a breadth, in its flattened condition, of three and a quarter inches across the middle of the outer chamber. The specimen preserves the filling of seven chambers, and is imperfect below, several having been removed. The occurrence of a species of this genus in rocks of this age is a matter of considerable interest. The only other known in this county, so far as we are aware, is the *G. obesum*, Bill., described in the Geological Report of Canada for 1857; but as we have not been able to compare it with a description of that species, we do not know how nearly this one may resemble it.

Formation and locality: In the upper part of the shales of the Hudson River group, near Dayton, Ohio. Ohio State collection. Collected by Prof. Edward Orton.

ENTOMOSTRACA.

GENUS LEPERDITIA.

SUB-GENUS ISOCHILINA.

LEPERDITIA (ISOCHILINA) CYLINDRICA.

Plate 4, fig. 5.

Leperditia (Isochilina) cylindrica, Hall; Descr. New Species of Fossils from the Hudson River Group, etc., p. 7.

Leperditia (Isochilina) cylindrica, Hall; 24th Rept. State Cab., p. 231, pl. 8, fig. 12.

The original description of this and the following species of bivalve entomostracans is copied from the above cited reports, as we have not seen any additional specimens, and the originals have been returned to their owners; consequently no new facts have been collected in relation to their characters or habits.

"Carapace minute, seldom exceeding two-hundredths of an inch in length, nearly twice as long as wide; valves very convex and cylindrical, the anterior and posterior ends sub-equal and strongly rounded; cardinal line much shorter than the length of the valve; tubercle obsolete." Surface smooth.

There appears to be no tubercle or prominence of any kind on the surface of this minute species, and so far as can be ascertained the valves do not overlap on the basal border; but as they have not been seen in connection, this feature on so small a species may easily be overlooked.

Formation and locality: In the Hudson River group, at Cincinnati. The original specimens were from the collection of Mr. C. B. Dyer.

LEPERDITIA (ISOCHILINA) MINUTISSIMA.

Plate 4, fig. 4.

Leperditia (Isochilina) minutissima, Hall; Descr. New Species of Fossils from the Hudson River Group, etc., p. 7.

Leperditia (Isochilina) minutissima, Hall; 24th Rept. State Cab., p. 231, pl. 8, fig. 13.

Carapace minute, less than two-hundredths of an inch in length, the width being about two-thirds the length, greatest at the anterior third, giving a broadly ovate outline, with a straight cardinal margin of about two-thirds the length of the valve.

Surface of the valves smooth, rising into an obtusely pointed prominence at the anterior third of the length; basal margins of the valves not overlapping, so far as can be ascertained.

Formation and locality: In the Hudson River group, at Cincinnati, Ohio. The original specimens were from the collection of Mr. C. B. Dyer.

GENUS BEYRICHIA.

BEYRICHIA TUMIFRONS.

Plate 4, fig. 8.

Beyrichia tumifrons, Hall; Descr. New Species of Fossils from the Hudson River Group, etc., p. 7.

Beyrichia tumifrons, Hall; 24th Rept. State Cab., p. 231, pl. 8, fig. 11.

Carapace small, sub-reniform or semi-elliptical; dorsal margin straight, nearly as long as the entire length of the valve; anterior and posterior extremities equal in width, or sometimes having the anterior a little wider; extremities sharply rounded; basal margin very broadly rounded. Surface of valves moderately convex, with a deep, narrow, marginal groove on the basal margin, which becomes obsolete on the ends before reaching the dorsal angles, leaving a sharp carinate border. Body of the valve strongly constricted by two deep, oblique sulci, the posterior one originating in the basal groove and extending obliquely backward two-thirds across the valve; the second extends entirely across the valve at about one-third the length from the anterior end, and is strongly curved backward in the middle, so that the anterior portion of the valve forms a rounded area, which is often the most prominent part of the body, though in some specimens the central ridge is equally prominent.

Surface minutely granulose. Length, six-hundredths of an inch; width, about three-hundredths.

This species differs from *B. oculifera* in being destitute of the prominent eye tubercle.

Formation and locality: In the Hudson River rocks, at Cincinnati, Ohio.

BEYRICHIA OCULIFERA.

Plate 4, figs. 9, 10.

Beyrichia oculifera, Hall; Descr. New Species of Fossils from the Hudson River Group, etc., p. 8.

Beyrichia oculifera, Hall; 24th Rept. State Cab., p. 232, pl. 8, figs. 9, 10.

Carapace small, seldom exceeding seven-hundredths of an inch in length, by three to four-hundredths in the greatest breadth, in the largest specimens; valves obliquely sub-reniform, broadest near the anterior end, with a straight hinge line, which is a little shorter than the greatest length of the valve; anterior end projecting beyond the hinge; center moderately convex, with a proportionally broad, deep channel, just within the margin, extending all around it, except for a short distance at the posterior extremity, near the dorsal margin. The body of the valve is crossed obliquely by two broad, deep furrows, having their origin on the dorsal margin, the posterior one situated a little more than one-third of the length of the valve from the posterior extremity, and extending fully two-thirds across it; the anterior furrow is situated just behind the anterior third of the length, and in its lower portion is more strongly curved forward than the other. Eye tubercle large, pedunculated, very prominent, and spreading at the top, its surface equal to about one-third the width of the valve, and its height at the posterior margin equal to the breadth at the top, while the anterior margin is but little elevated, giving an obliquely sloping circular surface, with a denticulated border. This surface, under a strong magnifier, is seen to be covered by fine, eye-like facets, similar to those of the eyes of trilobites of the genus *Illænus*.

This species is very distinct from any other described, in the form and strength of the transverse furrows, and especially in the great prominence of the club-shaped eye tubercle. So far as can be ascertained, it is the first species of this group of crustaceans in which the eye facets have been detected.

Formation and locality: In the shales of the Hudson River group, near Cincinnati, Ohio.

BEYRICHIA CHAMBERSI.

Plate 4, figs. 11, 12.

Beyrichia Chambersi, S. A. Miller; Cin. Quart. Jour. Sci., Vol. I., p. 234, fig. 27; July, 1874.*

Carapace minute, the extreme length not exceeding half a line, and the greatest width not more than two-thirds as much as the length. Form of the valves broad ovate, with one side, for a space equal to about one-fourth of the width of the figure, cut away, forming the straight hinge line, which is equal in length to about six-sevenths of the entire length of the carapace. Greatest width of the valve a little more than one-third of the length from the anterior end. Surface of the valves highly convex, most prominent near the middle of the length, crossed by three curving sulci, none of which reach the ventral border, the middle of the curve being directed toward the posterior extremity. The middle sulcus is stronger and much deeper than the others, while the posterior one is faintly marked, and situated at about the posterior third of the length. The anterior sulcus is short, comparatively deep, nearly semicircular, and situated within the anterior third of the length, and about midway between the cardinal and basal borders. From the anterior margin of this depression, or between it and the anterior border of the valve, there rises a strong, thickened, lanceolate, or scythe-shaped, curved spine, which equals in length two-fifths, or sometimes one-half, that of the entire valve. The anterior and posterior surfaces of the spine are convex, the latter most strongly so, while the lateral edges are sharp, and the ventral one generally deeply serrate, although a few specimens have been noticed without the serrations, perhaps from wearing. The margin of the valve is bordered by a thickened rim, within which there is often a slightly depressed channel. Surface of the crust smooth, or very finely granulose.

The species is remarkable for the strong, backward curving spine, situated close to the anterior border, and by this character alone can be readily distinguished from any other form known from the Silurian rocks of America. Several examples have been noticed where the spines have been broken away just above the base, and in this condition might be mistaken for a specimen of *B. oculifera*, to which it bears considerable

* Some months subsequent to writing this description, the species was described under the above name, *loc. cit.*, by S. A. Miller, and as our description had not been published before this time, his name will be used.

resemblance, both in size and general form, but the characters of the sulci will serve to distinguish them, as well as the rounded, disc-like character of the eye tubercle in the latter species.

Formation and locality: In the shaly matter, between thin-bedded layers of limestones of the Hudson River group, near Waynesville, Ohio.

BEYRICHTIA QUADRILIRATA (n. sp.).

Plate 4, figs. 6, 7.

Carapace minute, the larger individuals seldom exceeding three-hundredths of an inch in length, and often not more than that size. Form sub-quadrangular, longer than wide, the proportions being about as two to three, and a little the widest at the anterior third of the length. Dorsal margin straight, a little less than the greatest length of the valve; ends squarely rounded, and the basal line scarcely flattened. General surface of the valves flattened, but marked by transverse furrows, four in number, three of which are distinct and deep, extending across, or nearly across, the valve; the fourth is less distinctly marked and extends but little more than half way across the valve. The furrows divide the surface of the valves into transverse ridges, which are situated, one at each end, and one at each third of the length. Those situated at the ends are narrow and abruptly elevated; that at the anterior third of the length does not reach quite to the dorsal margin; while that of the posterior third is much the strongest, rapidly widens in the lower part, and divided along the middle by the fourth, or smaller furrow, which gives it the character of a strong ridge, bifurcating in the lower half. The central furrow is wider than the others, oblique in its direction, and somewhat curved in its course toward the ventral border. The margin of the valves is strongly and abruptly depressed below the general surface, forming a narrow, flange-like projection around the ends and basal portions. Surface of the crust not spinose or granulose under a lens of moderate power.

The species somewhat resembles *B. trisulcata*, Hall, from the Lower Helderberg group, in the general expression of the valves, but differs in the relative position of the furrows. The specimens vary considerably in the strength of the ridges, these, in some cases, being broad and rounded, as in the specimen figured, while in others they are sharp and narrow, leaving broader furrows between.

Formation and locality: In the shaly matter, between thin layers of limestone of the Hudson River group, near Waynesville, Ohio. Associated with *Beyrichia Chambersi* and *Ischilina cylindrica*, and *I. minutissima*, Hall.

GENUS PLUMULITES, Barrande; *Turrilepis*, Woodward.

Among the fossils from Cincinnati, received from U. P. James, Esq., are several detached plates of a species of the above named genus of Cirripedes. The specimens are minute, and mostly too imperfect for figuring. In examining other collections of fossils from the same place, a few imperfect fragments only have been detected. We are, therefore, able to give only an imperfect description of the species.

The specimens referred to appear to be the first of the genus recognized in this country, although long known in Europe, where they have attracted the attention of several eminent naturalists. They were for many years supposed to belong to the family *Chitonidæ*, and were so referred and described by M. L. de Koninck (Bul. de l'Acad. Royale des Sci., 1857), but in the Quart. Jour. Geol. Soc. London, 1865, p. 486, Mr. Henry Woodward refers them to the *Cirripedia*, under the generic name of *Turrilepis* there proposed, giving very clear reasons for considering them as Cirripedes, and not Chitons.

In the supplementary volume of the Crustacea of the Silurian System de la Bohemia, the author describes several species under the generic name of *Plumulites*, not recognizing Woodward's genus, as its characters were not defined or described by the author.

As the species now described is known only from detached plates, we have given an outline of a figure copied from Mr. Woodward's article above cited, to aid in giving a better idea of the general form than can be derived from the specimens examined. The general form of the body appears to have been elongate ovate, or elliptical, and is composed of four or more ranges of imbricating plates of a somewhat triangular form, the whole somewhat resembling in appearance and character a loosely arranged pine cone imbedded in the rock. The body has probably been furnished with a short pedicle at the lower extremity, but no evidence of such an appendage has yet been discovered.

PLUMULITES JAMESI (n. sp.).

Plate 4, figs. 1-3.

General form of plates triangular, with the apex a little inclined to one side, the lateral margins gradually and rapidly diverging from the initial point, one of them considerably longer than the other. Basal margin sigmoidal, the convex portion situated next to the longest lateral

face, the concave portion to the shorter, and the shorter lateral margin deflected downwards in some cases (probably the marginal row of plates).

The surface of the plates is flattened or slightly convex on the sides, and very faintly depressed along the middle, the whole marked by rather closely arranged, annulating, and scaliform transverse lines parallel with the basal or sigmoidal margin, and marking stages of growth. These transverse lines are usually faintest near the apex, and gradually increase in width with the increased growth of the plate, but in some cases they are quite irregular in their distances.

The length from the apex to the basal margin of the plate is usually a little greater than the transverse diameter, and seldom exceeds a sixteenth of an inch, the largest specimens seen not measuring a line in their greatest diameter.

Formation and locality: In the Hudson River group, at Cincinnati, Ohio. We have detected fragments of a species apparently identical on surfaces of Trenton limestone, from near Trenton Falls, New York, received from C. D. Walcott, Esq. The species is named in honor of U. P. James, of Cincinnati, Ohio.

GENUS CALYMENE, Brong.

CALYMENE CHRISTYI, Hall.

Plate 4, figs. 13-15.

Calymene Christyi, Hall; 13th Rept. State Cab., p. 119.

Calymene Christyi, Hall; 15th Rept. State Cab., pl. 10, figs. 2-5.

“General form elongate ovate, symmetrical; body gibbous, the pygidium equaling the length of the head. Head semicircular, the frontal border expanded and gradually narrowing on the sides, the posterior angles terminating in a short, sharp spine. Glabella wide, slightly narrowing toward the front, regularly convex, strongly defined by the dorsal furrows, a little concave in the middle of the base; occipital furrow well defined, nearly straight, and in right line with the cheek furrows; posterior furrow oblique, defined, but not deep, the middle one nearly rectangular to the axis, while the anterior one is but slightly indented. The posterior lobe is much wider than the middle one, and about the same width as the anterior one. Cheeks small. Eyes very prominent.

“Thorax with thirteen segments; the axis salient, and a little wider in the middle than the lateral lobes; the articulations of the latter flat, or slightly curving, for a little more than one-third their length, when they are suddenly bent downward.

"The pygidium is gibbous, semi-elliptical, with the axis very prominent, and marked by seven rings, the last one being longer and more prominent, with a minute, scarcely defined node at the extremity; lateral lobes marked by six flattened ribs, the last one of which is minute, the expansion being continued in a narrow, flattened border around the posterior extremity."

The above is a copy of the original description of the species. There may be some doubt in regard to the correct reference of this species to the genus *Calymene*, as many of its features would seem to ally it as closely to the genus *Homalonotus*. M. Barrande, in his great work on the trilobites of Bohemia, refers to that genus a species (*H. Bohemicus*) which bears a striking resemblance to this one. The facial suture, upon which considerable reliance is placed, has the character of the latter genus, rather than of that of *Calymene*, passing, as it does, around the front of the glabella, on the upper side of the head, instead of below. The form of the glabella is intermediate between that of the two genera, but most like that of *Homalonotus*, although there is evidence of three pairs of furrows in this species. The thoracic segments are very similar to *Homalonotus*, while the pygidium resembles more nearly that of *Calymene*. There is no described American form of either genera with which this species is readily confounded, as the general expression of the whole body is so distinct from any known species. The short spines at the posterior angle of the fixed cheeks is a feature often seen on well preserved specimens of *Calymene senaria*, as it occurs in the formations in the vicinity of Cincinnati, Ohio.

Formation and locality: In the Hudson River group, near Oxford, Ohio; and, so far as we are aware, it has not been found at any other locality.

GENUS DALMANIA, Emericch.

DALMANIA BREVICEPS.

Plate 4, figs. 16, 17.

Dalmania breviceps, Hall; Extr. 20th Rept. State Cab., p. 16, 1866; 24th Rept. State Cab., p. 223, pl. 8, figs. 15 and 16.

The following description is that originally given, as above cited:

"Body broadly ovate in general form, having its greatest width across the base of the cephalic shield. Head sub-crescentiform, the anterior margin very slightly produced in front of the glabella. Frontal lobe of glabella transversely elliptical, the breadth nearly twice as great as the

length, separated from the anterior lobe by deep, narrow furrows. Anterior lobe transversely sub-ovate, prominent; middle and posterior lobes obsolete; occipital ring narrow, distinctly defined.

"Eyes very prominent, with five lenses in the vertical range, but the number of vertical ranges can not be determined; palpebral lobe depressed. The outer border of the movable cheeks is thickened and rounded, and the space between the border and the eye depressed. The posterior spines long and broad, reaching to the sixth thoracic segment.

"Thorax with the axial lobe highly convex and the lateral lobes strongly geniculate, sub-equal in width, rapidly tapering posteriorly from the fourth or fifth segment. Segments curved forward on the top of the axial lobe, and the furrows on the pleura strongly marked.

"Pygidium obtusely pointed behind, the lateral borders inclosing an angle of about one hundred and twenty degrees, the anterior border rounded; the number of articulations not clearly defined, but apparently numbering about ten or twelve, besides the terminal one; those of the lateral lobes have been more numerous.

"The entire surface, so far as can be seen on the specimen, has been finely pustulose."

The species is peculiar in the shortness of the cephalic shield, and in the apparent absence of the middle and posterior lobes of the glabella. It differs conspicuously from *D. callicephala*, of the Trenton limestones of New York, in the possession of spines on the posterior angles of the cephalic shield. From *D. Carleyi*, Meek (Palæontology of Ohio, Vol. I., p. 170, pl. 14, fig. 2), it differs in the greater breadth of the head and glabella, and in the short, broad pygidium.

As the original specimen from which the description quoted above was taken is the only one seen by us, we can not add any other features to those already given.

Formation and locality: In the shales of the Hudson River group, upper portion, near Lebanon, Ohio.

GENUS PROETUS, Steininger.

PROETUS PARVIUSCULUS.

Plate 4, fig. 18.

Proetus parviusculus, Hall; Extr. 20th Rept. State Cab., p. 17, 1866; 24th Rept. State Cab., p. 223, pl. 8, fig. 14.

"Body, in general form, broadly ovate, widest across the base of the cephalic shield. Head sub-lunate, produced into long, sharp spines at

the posterior angles of the cheeks. Glabella elevated, broadly sub-conical, rounded in front, concave behind; furrows not visible.

"Eyes comparatively large and prominent, separated from the glabella by a somewhat deep groove; border of the head broad and flattened.

"Thorax having the axial lobe very prominent, narrower than the lateral lobes; segments scarcely arching forward in the middle; lateral lobes geniculate, and having the extremities of the pleura directed backwards and distinctly furrowed to near their outer extremities.

"Pygidium small, semicircular, regularly rounded behind, and the anterior margin straight to near the lateral angles, where it is abruptly curved backwards. Axial lobe narrow, not reaching to the posterior border of the shield, marked by five small annulations, with about the same number on the lateral lobes, which are less distinctly marked.

"Surface smooth, or very finely granulose."

We know of no American species resembling this one sufficiently near to require any comparison of characters. The Bohemian species *P. sculptus*, Barr., with which it is compared under the original description of the species, is sufficiently marked by the one less thoracic segment to prevent the possibility of mistake. In the original description above copied, by some oversight the number of segments is not mentioned in the description of the thorax. There are ten thoracic segments, strongly bent in the lateral portions, and terminating in sharp mucronate points directed obliquely backwards from the geniculations. From *P. Spurlocki*, Meek (Palæontology of Ohio, Vol. I., p. 161, pl. 14, fig. 12), it differs so strongly that there can certainly be no danger of confounding them.

Formation and locality: In the shales of the Hudson River group, at Cincinnati, Ohio.

FOSSILS OF THE CLINTON GROUP.

BRYOZOA.

GENUS RETEPORA, Lamarek.

RETEPORA ANGULATA ? Hall.

Plate 5, figs. 2-4.

? Retepora angulata, Hall; Pal. N. Y., Vol. II., p. 49, pl. 19, fig. 3.

Frond densely reticulated; fenestrules elongate, sub-rhomboidal, two to three times as long as wide, and pointed at the extremities, seldom measuring a line in length, and many of them not more than one-third of a line; bars strongly rounded on the poriferous side, less convex and finely striated longitudinally on the opposite face. Pores arranged in two or more lines, usually three, but often becoming crowded and irregularly disposed at the junction of contiguous parts, where there are often as many as five in the breadth of the bar; margins of the pores strongly exsert, the lower side forming a spur-like lip in the central ranges, while those of the lateral ranges have the outer lip extended and elevated, bringing that side of the margin to a level with the inner margin.

The specimens examined, although having considerable resemblance to *R. angulata*, still differ in several important particulars, such as not possessing the angular ridges between the pores, and in having the borders of the pores elevated, forming the spur-like projections which that species does not show. We, therefore, strongly suspect that it may prove to be a distinct species on the examination of other and more perfect specimens, in which case we propose for it the specific name *Daytonensis*.

Formation and locality: In the limestones of the Clinton group, Soldiers' Home, near Dayton, Ohio.

GENUS RHINOPORA, Hall.

(Pal. N. Y., Vol. II., p. 48, 1852.)

RHINOPORA FRONDOSA (n. sp.).

Plate 5, figs. 8, 9.

Bryozoum growing in thin, broad, irregular expansions, sub-palmate or sub-ramose; cellulose on one face only (no evidence of cells on the opposite side has been seen in any of the specimens examined). Cells small, oval, arranged in regular rows where not obstructed in their regular growth, their border not distinctly raised to form a lip, but appearing like the punctures made by a pin in the surface of a soft substance, when directed obliquely to the plane of the surface; spaces between the ranges of cells depressed, and a little less than the width of the cells. Surface of the frond traversed by depressed, ramifying grooves, at irregular distances, which are more deeply excavated than the spaces dividing the ranges of cells; grooves bifurcating at irregular distances, the bifurcations alternating on the opposite sides, and extending about a tenth of an inch along the face of the frond, between the cells. There are also distant, slightly elevated maculæ, irregularly disposed, but apparently having their centers at a bifurcation of one of the grooves; but all of the bifurcations do not form centers of maculæ.

The species bears considerable resemblance to *R. verrucosa*, Hall (Pal. N. Y., Vol. II., p. 48, pl. 19, fig. 1), from the same formation at Flamboro Head, Canada West; but differs in not having the distinctly elevated, oval, almost sac-like cells of that species, in the presence of the elevated maculæ, and in the more regular ramifications of the grooves on the surface. In that species this feature is composed of raised lines, instead of grooves.

Formation and locality: In the limestone of the Clinton group, near Dayton, Ohio.

GENUS STICTOPORA, Hall.

(Pal. N. Y., Vol. I., p. 79, 1847.)

STICTOPORA MAGNA (n. sp.).

Plate 5, figs. 5, 6.

Bryozoum forming broad, strong, somewhat rigid, bifurcating stipes, the sides or margins of which are parallel; bifurcations sometimes forming an angle of about twenty-five degrees, the inner margins of the branches almost or quite overlapping. At other places the branches or

divisions of the stipe are curved outward at the bifurcations, giving a much greater angle than in the forms above described.

Surface of the bryozoum cellulose, the cells arranged in vertical lines parallel to the direction of the stipe, and also forming horizontal lines across the stipe. Cell apertures oval, their distances from each other equal to the diameter of the aperture in the vertical lines, and still greater in the horizontal lines. The substance of the stipe, between the ranges of pores, is marked by two additional microscopic pores at the base of each cell aperture, or midway between the contiguous cells. This feature is one not before observed in any species of the genus, and will serve to distinguish this species from any heretofore described.

Formation and locality: In the Clinton group, at the quarries at the Soldiers' Home, near Dayton, Ohio. Collection of Prof. Edward Orton.

GENUS CLATHROPORA, Hall, 1852.

(Pal. N. Y., Vol. I.)

CLATHROPORA CLINTONENSIS (n. sp.).

Plate 5, fig. 7.

Bryozoum frondose, expanded, reticulate, with large oval openings passing entirely through the frond, forming the branches or divisions of the reticulations; substance of the branches between the openings about equal in breadth to that of the opening, or narrower—seldom wider. Surface of the frond cellulose; cells arranged in oblique lines, crossing the branches diagonally; from six to twelve of the cells can be counted in the width of the branch; apertures rhomboid oval.

All the examples examined have been separated through the center, on the plane of the frond, showing that they have a central dividing partition, the fronds being cellulose on both surfaces; and over the entire surfaces presented to view we see only the inner face, or base of the cells. The form and character of the cell aperture is taken from small spots where the entire substance of the bryozoum has been removed, leaving an imprint on the surface of the stone. The species differs from *C. frondosa*, Hall (Pal. N. Y., Vol. II., p. 160, pl. 40b, fig. 5), and also from *C. flabelata*, Hall (Fost. and Whit., Lake Sup., p. 207, pl. 24, fig. 2), in the narrower branches and the smaller number of cells in their width. The

general resemblance is much the same, but these differences distinguish it quite readily.

Formation and locality: In the limestones of the Clinton group, at the Soldiers' Home, near Dayton, Ohio.

GENUS PHÆNOPORA, Hall, 1852.

(Pal. N. Y., Vol. II., p. 46.)

PHÆNOPORA (PTILODICTYA) EXPANSA (n. sp.).

Plate 5, fig. 1.

FronD forming broad, elongate stipes, the entire length and form not determined, the larger fragments seen measuring nearly an inch in width, by nearly two and three-quarter inches in length, with a thickness of an eighth of an inch. The lateral edges are slightly irregular, but generally parallel in the specimens under consideration. Frond distinctly separated longitudinally into two parts by a thin, central partition extending from edge to edge, from the surfaces of which the cells take their origin, and diverge obliquely upward and outward to the surface of the frond.

Surface of the frond divided by thin, longitudinal partitions, forming the sides of the cells, and separating them into longitudinal rows. The outer edges of the partitions are slightly raised above the upper and lower walls of the cells, and count ten or eleven in the space of a tenth of an inch. Cells slightly oval, a little longer than wide, arranged in horizontal, or nearly horizontal, rows, diverging from the central partition at an angle of about fifteen degrees above a horizontal, but varying somewhat in different parts of the frond. There is an appearance of maculæ, or slightly elevated patches, on the surface, but they are not sufficiently distinct to determine their order or arrangement.

The species is of the type and somewhat resembles *P. constellata*, Hall, from the Clinton group of New York, but the fronds are larger and thicker, while the maculæ of the surface are much less distinct. It is possible, however, that if compared with more perfect specimens than we have seen, that it may prove to be more nearly allied than we have supposed.

Formation and locality: In the limestones of the Clinton group, near Dayton, Ohio.

BRACHIOPODA.

GENUS STROPHOMENA, Rafinesque.

STROPHOMENA PATENTA.

Plate 5, fig. 10.

Leptæna patenta, Hall; Pal. N. Y., Vol. II., p. 60, pl. 21, fig. 3b.*Strophomena patenta*, Hall; 12th Rept. State Cab., p. 82.

Shell of medium size, semi-ovate in outline, wider than long; valves resupinate, the ventral being concave beyond the middle of the shell. Hinge line as long, or longer, than the width of the shell below; front and sides of the shell rounded, the latter usually constricted just below the hinge line, forming ear-like extensions at the cardinal extremities. Width of the cardinal area not determined. Ventral side convex on the umbone and central region of the valve, but strongly recurved beyond the middle, forming a deeply concave shell in the more advanced stages of growth. Dorsal valve flat, or slightly concave, on the umbone, and strongly geniculate in front, conforming in curvature to that of the opposite valve. Surface marked by fine, closely arranged, bifurcating or implanted radiating striæ, which become somewhat coarser with the increased size of the shell; also by very fine, concentric, undulating striæ, often very distinct between the radiating lines, forming a beautifully cancellated surface when well preserved, and by several more distinct concentric lines, indicating stages of growth.

The species belongs to a group of Strophomenoid shells which are characterized by having the ventral valve convex in the young shells, while in the more advanced stages, or adult individuals, it becomes doubly flexed, and often deeply concave. The shells have much the form and character of those Silurian species referred to the genus *Streptorhynchus*, but differ from them very strongly in this particular of having a double curvature to the shell; and this feature will serve to distinguish this species readily from *Streptorhynchus subplana*, with which it is associated. The shells under consideration appear to be identical with those from New York, above cited, differing only in the somewhat finer radiating striæ of the surface. This difference, however, may be more apparent than real, as the New York examples are thoroughly silicified and the surface features somewhat obscured by this change.

Formation and locality: In the limestones of the Clinton group, at Dayton, Ohio.

GENUS RHYNCHONELLA, Fischer.

RHYNCHONELLA SCOBINA.

Rhynchonella neglecta, var. *scobina*, Meek; Am. Jour. Sci. and Arts, Vol. IV., p. 277, 3d series, 1872.

Rhynchonella neglecta, Meek; Pal. Ohio, Vol. I., p. 179, pl. 15, fig. 3.

In the American Journal, *loc. cit.*, Mr. Meek describes a species of *Rhynchonella* from the Clinton group, at Dayton, Ohio, under the name *R. neglecta*, var. *scobina*, but in the Palæontology of Ohio, as cited above, he drops the varietal name and fully identifies his shell with *R. neglecta*, Hall, from the Niagara formation of New York, principally on the evidence furnished by a minute surface character beautifully seen on the Ohio shell, stating that he had detected a similar texture on New York specimens of *R. neglecta*, loaned by Prof. Hartt, of Cornell University. We have examined, and in vain, many examples of well preserved *R. neglecta* from New York, and among them the original specimens used in description, to find any thing approaching the surface features of the Ohio species, and feel inclined to believe that the examples from New York on which the structure referred to was detected were *young* specimens of *R. cuneata*, a species very much more closely related to the shell under consideration than *R. neglecta*, and one on which this same structure is very strongly marked. But the shell differs, however, in the larger and adult individuals, in the peculiar character of the beak and area beneath it, from the Ohio specimens; still the short, broad forms of *R. cuneata* may very readily be mistaken when compared with the others, and the young would be difficult to separate. We, therefore, propose to restore the Ohio shell to its proper standing as a species, under the name *R. scobina*.

LAMELLIBRANCHIATA.

GENUS CYPRICARDITES, Conrad.

CYPRICARDITES FERRUGINEUM (n. sp.).

Plate 5, fig. 11.

Shell somewhat above the medium size, obliquely broadly ovate in outline, with very ventricose valves, and rather small, appressed beaks, which project but little above the cardinal line. Hinge line short, less than half the entire length of the shell; rounded at the posterior end, and gradually passing into the posterior border, which is somewhat

oblique to the body of the shell; anterior end proportionally long and full, faintly separated from the body of the shell by a very slightly marked sulcus, which crosses the anterior portion of the valves; body of the shell very full, almost inflated in the central part; the umbonal region the most prominent, slightly angular for a short distance below the apex, caused by an oblique flattening of the anterior side of the beak; posterior slope concave between the postero-cardinal angle and the body of the shell. Cardinal area and hinge characters unknown.

Surface of the valves marked by very strong varices, or concentric undulations of the surface, indicating stages of growth.

The species is most nearly related to *C. Saffordi* (= *Palæarca Saffordi*, Hall, 12th Rept. State Cab., p. 11; see, also, Pal. N. Y., Vol. III., p. 524; = *Cyrtodon Saffordi*, Safford, Geol. Tennessee, p. 287, pl. F, fig. 2), but differs in being more extended on the anterior end, in the greater obliquity of the body of the shell, in the flattening or compression of the anterior side of the beak, in the greater prominence of the umbonal region, in the depression of the postero-cardinal slope, and in the faintly marked sulcus crossing the anterior portion of the valves.

Formation and locality: In the iron ore beds of the Clinton group, at Wilmington, Clinton county, Ohio. Ohio State collection. Collected by Prof. Edward Orton.

GASTEROPODA.

GENUS PLEUROTOMARIA, DeFrance.

PLEUROTOMARIA INEXPECTANS (n. sp.).

Plate 5, fig. 12.

Shell of medium size, very broadly conical above the middle of the last volution, and abruptly rounded below. Spire moderately elevated, the line of the opposite sides inclosing an angle of about eighty-five degrees, or a little less than a right angle. Volutions rather rapidly increasing in size, thickened, and slightly elevated at the upper margin, forming a raised band just below the suture line, thence regularly sloping to the periphery, which is obtusely angular. Lower side of the volution very ventricose, and regularly rounded to the umbilical region, which is filled by a small callus that appears to spread over and cover the columellar lip. Aperture forming more than one-third of the entire height of the shell, regularly rounded, except above the center of the outer border, where it is slightly flattened, corresponding to the upper sloping surface

of the volution, and sub-angular at the junction of the upper and lower surfaces of the outer lip.

Surface of the shell marked on the upper part of the volutions by a series of raised, revolving lines of varying strength; and crossed by equally strong, concentric lines, which are directed obliquely backwards from the suture to the periphery, where they are more abruptly bent back to the center of the carina, below which they are as abruptly directed forward, indicating a moderately deep but narrow notch in this part of the lip of the aperture. On the lower side of the volution the concentric striæ can be traced for a short distance, below which the shell is imperfect in both individuals examined. No evidence of revolving lines below the central band has been seen, and the probability is that none have existed on this portion of the shell.

The species is very closely related to *P. Hebe*, Hall, 15th Rept. State Cab., pl. 5, fig. 8, and also to *P. sulcomarginata*, Conr., figured on the same plate, and is, so far as we are aware, the only species of this type of the genus recognized in this country from a formation below the Upper Helderberg group. It differs from both of the above named species in the greater elevation of the spire.

Formation and locality: In the iron ores of the Clinton group, Clinton county, Ohio. Collection of U. P. James, Esq.

CEPHALOPODA.

ORTHOCERAS JAMESI (n. sp.).

Plate 5, fig. 13.

Shell small, and very moderately expanding with increased growth, the fragment used in description being only about five-eighths of an inch in length, with a diameter of five-sixteenths of an inch at the upper end, and a little less than a quarter of an inch at the lower extremity of the fragment, giving about a twelfth of an inch increase in diameter in the length of the specimen. Transverse section circular, not compressed. Septa very moderately and evenly concave, apparently regularly disposed, about three and half of the chambers occupying a space equal to the diameter of the shell at the top of those measured. Siphuncle not clearly determined.

Surface of the shell rather coarsely, but deeply and beautifully, cancellated by sharp longitudinal and transverse ridges, the former nearly reg-

ularly disposed, varying but little in their distance from each other, and counting about eighteen in one-half of the circumference of the shell, the spaces between the ridges deeply concave, and sometimes showing evidence of finer intermediate striæ. The transverse ridges are as strongly elevated as the longitudinal ones, but less angular on the crest, more distantly and irregularly disposed, the intervening spaces being sometimes two or three times as great as the narrowest spaces observed on the fragment, the spaces between them finely striated, the striæ undulating between the longitudinal ridges.

The species appears to be of the same type with *O. columnare*, Hall, but differs from any species of that group yet described, in the strong, irregularly arranged, transverse ridges, and the greater number of longitudinal ridges. The species of that group known have the fine transverse striæ crossing the longitudinal flutings, but we believe there are none known having the transverse ridges.

Formation and locality: In the iron ore beds of the Clinton group, Clinton county, Ohio. Collection of U. P. James, Esq.

CRUSTACEA.

GENUS ILLÆNUS, Dalman.

ILLÆNUS DAYTONENSIS (n. sp.).

Plate 5, fig. 14-16.

Among the fossils obtained from the quarries at the Soldiers' Home, near Dayton, detached specimens of the glabellæ and pygidia of a species of Illænus are not uncommon. The glabella is wider than long, and quite regularly rounded in front, between the junction of the suture lines with the anterior margin of the head, the surface being highly convex, with a slight tendency to gibbosity in the middle, when viewed sideways. The dorsal furrows on the cast are broad and strongly marked, extending about one-third of the length of the head from the posterior margin, and terminating anteriorly in a rather large oval depression, the space between them more abruptly convex than in front. Posterior margin between the furrows more strongly rounded than the front of the head, the whole occipital border being deeply trilobed, from the depressions of the dorsal furrows in the margin. Fixed cheeks a little more than half as wide as the space between the dorsal furrows, strongly convex opposite and posterior to the eyes, not distinguishable from the other por-

tion of the glabella forward of the dorsal furrows. Palpebral lobe small, pointed, and sharply elevated above the general surface of the head, situated very near the posterior margin. Suture line gently and regularly curving inward for a short distance in front of the eye, and then as gently outward again, giving to the glabella a little greater width anteriorly than immediately in front of the eye, the junction with the anterior margin making no perceptible angle. The direction of the suture line posterior to the eye, and the form of the postero-lateral limb of the glabella, have not been determined.

The pygidium associated with this form of glabella, and supposed to belong to the same species, is somewhat longer than semicircular in form, the length being a little more than two-thirds as great as the extreme width. General surface depressed convex, with rather strong depressions defining the axial portion on the anterior fourth of the length, but gradually fading away before reaching the middle of the plate. Anterior margin nearly straight, the axial portion slightly protruding beyond the line of the lateral lobes, which are straight for a little more than half their width, beyond which they are strongly and obliquely truncate. No portion of the thorax has been observed.

The specimens resemble *I. Taurus*, Hall, in many of their characters, as the small, pointed, and projecting eyes, placed so far back on the head, and in the trilobation of the caudal plate in its anterior part, but the glabella is very much longer in proportion to the width, as is also the pygidium, and the antero-lateral truncations of the latter are not more than half as large as in that species. The facial sutures of the head also differ very materially. In that species it is directed from the front of the eye, with a very moderate curvature, inward, meeting the anterior border of the head at a point which gives a width on the margin of but little more than half that immediately in front of the eye, while in this species the breadth near the anterior margin is greater than immediately in front of the eye prominence. The pygidium resembles, slightly, small specimens of that of *I. imperator*, Hall, but is much longer in proportion to its width.

Formation and locality: In the limestones of the Clinton group, near Dayton, Ohio. Specimens having the same features have been collected from the Niagara group of Wisconsin and Illinois.

FOSSILS OF THE NIAGARA GROUP.

The organic remains of the Niagara group of Ohio have a much greater resemblance to those of the same formation in Illinois, Wisconsin, and Iowa, than to those of the more eastern extension of the formation in New York. The greater similarity of condition and composition between the Ohio beds and those of the western localities would at once lead one to suppose this would be the case; the formation in the two regions corresponding in lithological characters, while they are quite dissimilar to the more fossiliferous shaly beds of New York. So far as yet known, the fossil remains appear to be much less numerous in Ohio than westward, but the localities have, as yet, been but imperfectly examined, and in all probability the number of species will be found to be much greater when the examinations shall have been as complete as they have been in many of the more western localities. One of the noticeable features presented, in looking over a collection of the fossils of the Ohio rocks of this group, is the scarcity of Brachiopodous shells, as compared with collections from New York; and more especially the sparse occurrence of the genus *Spirifera*, which in both the New York and western localities is represented by several species. Another peculiar feature is the small number of Crinoidal remains, and especially those of the peculiar group of Cystideans, which is so abundantly represented in the Wisconsin region. Of this latter group there have been but few species recognized, one of which, *Gomphocystites glans*, has been recognized in several individuals; and another, resembling *Holocystites Winchelli*, in two or more specimens, and a few individuals of *H. alternata*. Besides these, there is known a single impression of a Cystidean, apparently belonging to the genus *Callocystites*, and closely resembling if not identical with *C. Jewetti*. Heretofore this genus has been recognized only in New York.

The class Cephalopoda is represented by several new forms, and by some of those which have been described from other localities. The species are much more numerous than in New York, and, judging from the number already collected, will, when the localities are more completely examined, and the collections as carefully made, compare very favorably with those from any of the western localities. The small number of

Trilobitic remains is another marked feature. But very few species, and not many individuals of a kind, have yet been observed. In some localities, however, the *Caleymane Niagarensis* appears to be not uncommon, but, as yet, it appears to be the only abundant species.

GRAPTOLITIDÆ.

GENUS INOCAULIS, Hall.

(Pal. N. Y., Vol. II., 1852.)

INOCAULIS BELLA (n. sp.).

Plate 6, fig. 2.

Frond small, diffusely branched, originating in a single stipe at the base and spreading above; branches narrow, and varying much in width, the strongest not exceeding three hundredths of an inch, with frequent projecting, prong-like processes rising from the sides; bifurcations numerous and at varying distances. Substance of the frond thin, carbonaceous; the surface marked with longitudinal corrugations, irregularly disposed on most parts and on some of the larger branches, terminating at the upper end in a pustule or free point, projecting outward and upward from the surface.

The only specimen of the species examined is a beautiful, small frond, measuring about two inches across transversely, with a height less than the width. The mode of growth and style of branching is similar to that of *I. plumosa*, of the Niagara group of New York; but the surface does not present quite the regularity of leaf-like projections seen on that species, the corrugations showing more like the surface markings seen on some species of *Dictyonema*, although the mode of growth and the entire absence of connecting filaments between the branches at once distinguish it from species of that genus.

Formation and locality: The specimen occurs on the shaly surface of a fragment from a band of blue limestone in the Niagara group, at Yellow Springs, Ohio, and is from the collection of Prof. Edward Orton.

FORAMINIFERA.

GENUS RECEPTACULITES, DeFrance.

RECEPTACULITES OHIOENSIS (n. sp.).

Plate 6, fig. 1.

Body usually hemispherical in form, or approaching dome shaped, occasionally globular; those of the latter form being small, and probably young. Cells of medium size, varying in different parts of the body; arranged in concentrically curved, radiating lines; extending from the center of the dome to the point of greatest diameter, below which they form vertical and horizontal lines; the cells being smaller and more crowded, forming transversely elongated quadrangles encircling the body.

The appearance of vertical and horizontal rows of cells on the smaller individuals, and on the lower part of the larger ones, is probably deceptive, and owing in part to the greater obliquity of the ranges, to the peculiar structure of the cell apertures, and in part to the presence of crystalline matter adhering to the surface of most of the individuals examined.

The species is readily distinguished from any of those previously described, by its small size and hemispherical form in all but the very young stages, except from *R. hemisphericus*, Hall (Geol. Rept. Wis., 1861, p. 16), from which it differs very materially in the much smaller size of the cells; neither does it ever attain to the same dimensions as that species; the largest individuals yet noticed not exceeding one and a quarter inches in diameter, while those frequently measure over two inches. The small globular forms, which we suppose to be the young, resembles *R. globularis*, Hall, *loc. cit.*, from the Galena limestone, but the cells in that species are nearly double the size in specimens of the same dimensions.

Formation and locality: In limestones of the Niagara group, at Yellow Springs, Ohio. Collections of Prof. Edward Orton and Columbia College.

ECHINODERMATA.

CRINOIDEA.

GENUS PLATYCRINUS, Muller.

PLATYCRINUS PRÆMATURUS (n. sp.).

Plate 6, fig. 3-6.

Body of medium size, depressed oblate, and in a basal view strongly pentalobate, from the thickened tumid character of the first radial plates, which form the largest or widest part of the body, and above the middle of which the cup is strongly and rapidly contracted to the arm bases. Basal plates large, but forming only a small proportion of the height of the cup, their centers tumid, and projecting below the top of the column in the form of three strong, rounded nodes, the sutures between being strongly marked, but not abrupt. First radial plates large, much wider than long, and equal in height to about one-half of that of the cup; their upper lateral angles truncated by the interradial plates, and the centers excavated for the reception of the second radials, between which and the interradial plate the lower end of the supraradial plate on each side reaches to and rests upon the first radial. Second radial very small, rounded, triangular, pointed above, and higher than wide; occupying the center of the upper margin of the first radials, and not more than one-quarter of the width; supporting on each of the two upper sloping faces one side of the first supraradials, which meet above the point, the lower end resting on the first radial, and the outer side against or on the interradial plate. On the upper faces of the first supraradials rests a second pair, which are excavated on their upper sides for the plates of the arms. Interradial plates proportionally large, the general appearance being that of a triangle, higher than wide, but in reality they are hexagonal, resting on the two adjacent first radials and between the first supraradials of the adjoining rays, and supporting two smaller plates on the upper faces and between the second supraradials of the two adjacent rays.

Surface of the basal plates tuberculose; the tubercles having their longest diameter in the direction of the greatest length of the plate. Surface of the first radials much thickened and tumid, the tumidity extending to the margins of the plates and occupying the entire surface. Above the first radials the plates are strongly convex, but do not ap-

proach tumidity, the convexity extending over the entire surface without channeling or chamfering of the edges. The general surface of the body is smooth, or very finely granulose.

The above characters of the external surface and form of plates are taken from gutta-percha impressions made in the natural molds left in the rock by the removal of the substance of the crinoid by solution, and differ very materially from the casts of the interior of the body, as usually found. These casts occur not uncommon in the form of flattened or depressed spheres, or oblate bodies, preserving only the markings of the suture lines, without showing any of the external features other than the arrangement of the plates, while these even are mostly obscure, and can only be traced with difficulty. But where the matrix can be obtained, and impressions made in them, the true features of the species are obtained. At present we know nothing of the arms of the species or the form of the column.

Formation and locality: In the limestones of the Niagara group, near Greenville, Darke county, and at Cedarville, Greene county, Ohio. Collected by Rev. H. Hertzner.

GENUS SACCOCRINUS, Hall.

(Pal. N. Y., Vol. IV., p. 205, 1852.)

SACCOCRINUS TENNESSEENSIS.

Plate 6, fig. 10.

Saccocrinus Tennesseeensis, Troost, MS., p. 29.

Body elongate obconical, gradually enlarging from the base to the origin of the free arms, or sometimes slightly inflated above the middle, or near the arm bases. Dome flattened, constricted between the arm bases, and surmounted by a small central or sub-central proboscis. Plates of the body elongate, those of the radial series being much longer than wide; the second radials hexagonal, the third heptagonal in most, if not all, cases. Supraradials smaller than the upper radials, two in each series, arranged one above the other, the uppermost being a bifurcating plate, and supporting on each sloping face a smaller plate, from which rises the free arms, thus giving four arms to each ray at their origin, or twenty to the entire body. Interradial series consisting of a single first plate, which is intermediate in size between the first and second radials, and hexagonal in form, supporting two plates in the second, and subsequent ranges, to the number of five ranges, the plates in each

range gradually decreasing in size upwards. Anal area larger than the interradials; the first plate large, usually supporting three in the second range, above which they are not so regularly disposed, and gradually decrease in size. The constriction between the arm bases on the anal side is much larger and deeper than those of the interradial areas.

The dome appears to have been composed of a large number of small polygonal plates, without any definite arrangement or order. The arm bases are small, indicating slender arms, their structure and form unknown. As the specimens consist only of internal casts of the body, the surface features of the plates have not been observed, as no parts of the matrix has been preserved in collecting.

The general form of the body and plates corresponds exactly with the form in Dr. Troost's collection, and with the figures and MS. description of his *Actinocrinus Tennesseensis*. The form described as *A. (Sac.) Christyi*, Hall, is more spreading towards the top of the cup, but the dome of that species is seldom preserved; the other features correspond more nearly in the two forms.

Formation and locality: In the limestones of the Niagara group, at Yellow Springs, Ohio. Collection of Prof. Edward Orton.

SACCOCRINUS ORNATUS (n. sp.).

Plate 6, fig. 7-9.

Body of medium size, obovate, or elongate urn shaped below the arm bases; obscurely pentangular in the upper part of the cup, from the flattening of the interradial areas; the body surmounted by a long, very slender proboscis. Basal plates of moderate size, forming about as much of the height of the cup as the width of one of the plates. Plates of the radial series elongate, the first ones much larger than any others in the body; second and third about of equal size, but differing slightly in different rays; the third plate is obtusely cuneate above, and supports two sub-radials on each side, one above the other, the first being about two-thirds as large as the third radial, the other about half as large as the first, and supports the free arms, one on each division of the ray, giving ten arms only to the body at the margin of the cup. Between the second supraradials there is a single small intersupraradial to each division. The interradial series consists of a single first interradial plate, which is about equal in size to the second radials, hexagonal in form, and supporting two plates in the second, third, and fourth ranges, with sometimes one, two, or three very small ones in the fifth, high up

between the arm bases. The anal area is much larger than the inter-radial areas, and consists of a first plate, nearly equaling in size that of the first radials, and supports three in the second and five in the third range, above which point they are not so regularly disposed, but the central plates of the area form a direct line with the first anal plate, and along the middle of the proboscis, for some distance above its base. The proboscis is very long and slender, composed of elongate polygonal plates, of which there are four or five in a series near the base, but often not more than three in the upper part. The proboscis preserved in the specimen described is nearly an inch and three-eighths long, and still imperfect at the upper extremity, where it is less than an eighth of an inch in diameter.

The general surface of the plates of the body is highly convex, with deeply channeled sutures, the smaller ones, near the upper portion of the cup, and on the dome, being very convex. The surface of each plate is also ornamented by a system of radiating lines, those meeting at the center of the plate extending to the angles. On some of the plates there is an appearance of intermediate lines, the number of which can not be determined.

The species is described from an internal cast and a gutta-percha impression of the exterior obtained from the matrix of the same individual, which gives the form and surface of the plates. The arm bases, including the intersupraradial areas, are elevated, and project beyond the general level of the body, giving a somewhat pentalobate feature to this part of the body. The impression of a fragment of the column is preserved, and shows that this appendage was of medium size, and composed of alternating larger and smaller plates.

The species most nearly resembles *S. speciosa*, Hall, from the Niagara shales of New York, but differs very materially in the external features of the plates composing the body. In that species the plates of the body are flat, or have only the general convexity of the cup, and marked with indistinct radii, while along the radial series a low, rounded, rather indistinct ridge passes to the bases of the arms, and the arm bases do not protrude beyond the general surface until they reach the top of the second supraradial plate, while in this species the protrusion commences with the third radial plate itself. From *S. Christyi*, Hall, it differs in having only two arms to the ray at the top of the cup, instead of four, as in that one. It also differs in this respect from *S. Tennesseeensis*, Troost.

Formation and locality: In limestones of the Niagara group, at Yellow Springs, Ohio. Ohio State Cabinet. Collected by Prof. Edward Orton.

GENUS EUCALYPTOCRINUS, Goldf.

EUCALYPTOCRINUS SPLENDIDUS, Troost.

Plate 6, fig. 12.

Eucalyptocrinus splendidus, Troost; Proc. Am. Assoc. Adv. Sci., 1848, p. 60.

Calyx low and spreading, cyathiform, or nearly hemispherical, about twice as wide as high, measuring to the base of the arms; sides somewhat regularly rounded; base slightly impressed for the reception of the column. Above the calyx the edges or backs of the interbrachial plates are nearly vertical, giving a breadth just below the top of these plates but little less than that at the summit of the calyx. Oral (?) aperture, at the center of the summit of the interbrachial plates, broad funnel-form, communicating with the cavity of the body by means of a long, rather large, canal. Basal plates of the calyx very small, concealed within the cavity of the column; first radial plates forming the base of the cup and reaching but a short distance up the sides; second radials quadrangular, a very little wider than high; third radials pentangular, with the apex truncated by the smaller interbrachial plates, and supporting on the lateral faces the smaller pentangular supraradials, which in turn support the plates on which the free arms rest, two to each division, or four to each ray. Interradial plates large, higher than wide, broadest above the center, supporting two elongate intersupraradials, which in turn support the larger interbrachial plates. Arms unknown, from Ohio specimens.

The specimen from which the description is taken is, so far as we are aware, the first example of the species recognized, aside from the original specimen in Dr. Troost's collection. It is an internal cast, preserving the filling of the internal cavity of the body, the impressions of two of the interbrachial plates, and the filling of the central canal leading from the summit aperture to the interior of the body, the upper portion of the specimen having been split vertically through the center. It shows the form of the internal cavity, and the form and size of the canal leading from it to the summit or oral aperture, and forms on the whole a very interesting specimen.

The species is chiefly distinguished from others of the genus by the vertical line of the back, or outer face, of the interbrachial plates, those on the opposite sides of the body being parallel with each other. All other species known from rocks of the same age in this country are more or less contracted, or inclined inward toward the top, giving

a narrow summit, while in this one it is broad, and flattened for a space equal to two-thirds the breadth of the body below.

Formation and locality: In limestone of the age of the Niagara group, at Springfield, Ohio. Collection of Prof. E. Orton. Presented by Charles Cline, Esq.

EUCALYPTOCRINUS CRASSUS.

Plate 6, fig. 11.

Eucalyptocrinus crassus, Hall; Trans. Alb. Inst., Vol. IV., p. 197.

Body narrowly obconical, the height below the bases of the arms equal to the greatest diameter of the cup; sides straight, or slightly convex; base truncate. Basal plates small, concealed within the cavity for the attachment of the column; first radial plates of moderate size, forming about one-fourth of the height of the calyx; second radials quadrangular, widest below, the height a little greater than the breadth; third radials pentangular, truncated above by the small intersupraradial plate, and supporting on each sloping face a supraradial plate, which in turn supports the plates from which the arms rise. Interradial plates large, half as high again as wide, and supporting two elongate interbrachial plates. Arms and interbrachial plates not seen. Surface of the plates of the calyx, so far as can be ascertained from a fragment of the matrix, apparently smooth.

The specimen being only an internal cast, the entire characters can not be obtained. It has the general appearance and structure of *E. crassus*, as above cited, and the form of one of the narrow or elongate varieties of that species, which is very variable in the proportions of height and breadth of the cup, and, consequently, in the proportion of diameters of the plates composing it.

Formation and locality: In the limestones of the upper part of the Niagara group (Guelph beds), at Cedarville, Greene county, Ohio. Collected by Prof. E. Orton.

BLASTOIDEA.

GENUS PENTREMITES, Say.

PENTREMITES SUB-CYLINDRICA (n. sp.).

Plate 6, fig. 13.

Body elongate, very gradually tapering from the base of the ambulacral areas downward to the lower end of the radial plates, and more rapidly below that point to place for the attachment of the column;

above the base of the ambulacral areas the summit forms a short five-sided pyramid, with slightly concave spaces between the ambulacral areas. Radial plates long and narrow, three and a half times as high as wide; length of basal plates unknown; height of the summit pyramid a little more than half as great as the greatest diameter of the body; while the diameter of the body is about equal to three-fifths of the length of the radial plates, measuring at the base of the ambulacral areas. Ambulacral areas narrow, gradually increasing in width from the lower part upwards; number of plates filling the areas not determined.

The description is taken from an internal cast, imperfect at the lower extremity, and, consequently, a full description can not be given. The form of the crinoid corresponds very nearly with that of *P. Reinwardti*, Troost, and it is principally the interest connected with the occurrence of another species so nearly allied to that one, in a similar geological position, that has offered the temptation to describe it from such meager material. The general form of the body has been much straighter above the basal plates, when compared with that one in the condition of casts, and the top of the summit pyramid considerably broader.

Formation and locality: In limestones of the Niagara group, at Yellow Springs, Ohio. Collection of Prof. E. Orton.

BRACHIOPODA.

GENUS DINOBOLOUS, Hall.

(Notes on some new or imperfectly known forms among the Brachiopoda, etc., p. 4, 1871; also 23d Rept. State Cab., p. 247.)

DINOBOLOUS CONRADI.

Plate 7, figs. 3, 4.

Obolus Conradi, Hall; 20th Rept. State Cab., p. 368, pl. 13, figs. 1, 2, 3, 1868, and 2d Ed., 1870, p. 375.

Dinobolus Conradi, Hall; 23d Rept. State Cab., p. 247.

A single individual of this species has been detected among specimens from the Niagara group, at Crawford, Wyandot county, Ohio, preserving the usual features of the species, so far as can be determined from the imperfect condition of the specimen. The individual consists of an internal cast of both valves of a full-grown shell, but displaced and quite imperfect. The form is transversely broad oval, very symmetrical in outline, and gently convex on both sides; giving a lenticular profile to

the united valves. The specimen referred to measures about an inch and a half in transverse diameter, by about one inch and three-eighths from beak to base on the dorsal side. The projection of the beak on the ventral side would make the length and breadth about equal. As the specimen will be mostly in the condition of casts of the interior, they will show the features of the interior of the shell; or, in other words, the impression of the interior surface. In the middle of each valve, and extending from near the beak to the center, or beyond the center of the shell, there is an elongate triangular depression, with two obtusely pointed, triangular processes rising from the lower part of the depression, one on each side, and having their extremities directed toward the beak. These processes are closely appressed to the surface of the cast when preserved (but are frequently broken), and are very thin. The surface outside of the depression is regularly convex, except near the rostral portion, where it slopes abruptly to the level of the hinge plate, and shows on the ventral side the rounded or convex triangular space left by the depression of the triangular, foramen-like area beneath the beak. The triangular depressions in the middle of the valve is formed by the removal of the internal transverse muscular plates, or transverse septum, which has been supported along the middle by a vertical partition, with cavities on each side beneath the plate, the two triangular processes having filled these cavities. The form and proportion of this plate has varied considerably among different individuals of the species, as is seen by the depressions left in several specimens examined from the typical localities. The discovery of this species, and a species of the genus *Monomerella* (*M. Newberryi*), at the same locality, is a matter of considerable interest, when taken into consideration with the occurrence of such numbers of *Trimerella* at other localities of the formation in other parts of the State, giving reason to expect the development of all these forms in some one locality if properly sought for.

GENUS MONOMERELLA, Bill.

MONOMERELLA NEWBERRYI (n. sp.).

Plate 7, figs. 1, 2.

Shell elongate orbicular, approaching oval in outline, with depressed convex valves, giving a lenticular profile. Dorsal valve a very little more ventricose than the opposite, and fullest on the umbonal region. The muscular plate in the interior of the dorsal valve, judging from the form of the internal cast, has been very large and broad, apparently

reaching to near the front of the valve, and extending fully two-thirds the width of the internal cast in its broadest part. The projections which have filled the cavities beneath the plate, if existing, are not observable, indicating a closely appressed plate, or one not at all elevated or separated from the body of the shell. The ventral valve is characterized in the cast by the great length of the processes which have filled the cavities beneath the plate, showing that the beak has been extended far beyond that of the dorsal valve, and that these cavities have passed to a considerable distance beyond the hinge plate. The plate has been very short and thickened, as indicated by the elevation of the processes above the line of the hinge when viewed in profile. The processes are thin and compressed toward their apices, but near their junction with the other portion of the cast are thick and expanded.

The dorsal valve of this species resembles very much a valve of *Dinobolus*, with the short triangular processes beneath the plate broken away, and if found separate from the opposite valve would undoubtedly have been considered as belonging to a specimen of that genus, having a very deep umbonal cavity. The ventral valve differs from the corresponding valve of that genus only in the greater size and cardinal position of the processes filling the cavities beneath the plate. It differs from *Dinobolus Conradi*, Hall, externally, in being elongate oval instead of transversely oval. Not having seen the description of the species of *Monomerella* described by Mr. Billings, or figures of the same, we are unable to say in what particulars it may correspond to or differ from that one. The structure of the valves and processes in this species would seem to tend toward the union of some of these forms that have been considered as distinct genera.

Formation and locality: In the limestones of the Niagara group, at Genoa, Ohio. Collection of Columbia College, New York.

GENUS MERISTINA, Hall.

(20th Rept. State Cab. N. Y., p. 157, 1867; Pal. N. Y., Vol. IV., p. 299, 1867.)

MERISTINA MARIA, Hall.

Plate 7, figs. 5, 6.

Meristella maria, Hall; Trans. Albany Inst., Vol. IV., p. 212, 1862.

Meristella maria, Hall; Abstr. Trans. Albany Inst., p. 18.

Meristina maria, Hall; 20th Rept. State Cab., p. 157, 1867.

Meristina maria, Hall; Pal. N. Y., Vol. IV., p. 299, 1867.

The specimens of the species observed from Ohio are in the condition of internal casts, and present the features of the interior of the shell

only. The features of the muscular imprints and the cavities left by the removal of the septa and other processes are well marked. The form is triangularly ovate, or sub-quadrangular. Valves convex, nearly equally so; the front of the ventral being bent upwards, forming the sinus of this valve, and causing a slight elevation or fold on the dorsal, which extends about half the distance to the beak. Cardinal margins of the ventral valve angular, corresponding to the angulation of this part of the shell, while the surface of the valve across the umbo is nearly flat from side to side, except for the projection of the muscular impression. The beak is short and not recurved, consisting only of the filling of the rostral cavity. Dorsal valve most convex on the umbo and along the middle of the valve, and in old specimens rapidly sloping to the lateral margins, the beak showing a strong slit corresponding to the median septum.

Formation and locality: In limestones of the Niagara group, Springfield, Ohio. Collection of Prof. E. Orton.

GENUS ATRYPA, Dalman.

ATRYPA NODOSTRIATA.

Plate 7, figs. 12-14.

Atrypa nodostriata, Hall; Pal. N. Y., Vol. II., p. 272, pl. 54, fig. 2, 1852.

Shell small; transversely very broad oval in outline; bi-convex in profile, somewhat unequally so, with a low rounded elevation on one valve and a corresponding depression on the other. Ventral valve less convex than the opposite; beak small and projecting; center of the shell marked by a rather wide, very distinct mesial depression, extending from near the beak to the front of the valve, which is abruptly bent upwards, forming a broad, rounded, linguiform extension, fitting into the elevated portion of the other valve; sides of the mesial depression sub-angular; outside of which the surface of the valve is somewhat depressed or concave to the sides and cardinal margins. Dorsal valve rather regularly convex, the middle portion elevated, forming the fold, which is not conspicuous beyond the center of the valve, but is somewhat distinctly marked and rapidly narrowed.

Surface marked with bifurcating, rugose, radiating striæ, which often form fasciculæ at or about the middle of the shell. The striæ are strong and apparently rounded, most distinct on the dorsal valve, and somewhat strongly marked toward the front of both valves.

The specimens of this species which have been observed are in the condition of casts of the interior, and, of course, the surface features are more or less obscured; but on specimens at all well preserved the fasciculate character of the striæ is readily recognized, and the mesial fold and sinus very distinct, the margins of the fold being often quite angular. These features, and especially the coarse fasciculate striæ, will serve to distinguish the species from any other shell found associated with it.

Formation and locality: In the limestones of the Niagara group, at Yellow Springs, Ohio, and also in the Clinton group, at Dayton, Ohio. Collected by Prof. E. Orton.

GENUS RHYNCHONELLA, Fischer.

RHYNCHONELLA NEGLECTA.*

Plate 7, fig. 15.

Atrypa neglecta, Hall; Pal. N. Y., Vol. II., p. 274, pl. 57, fig. 1, 1852.

Rhynchonella neglecta, Hall; 12th Rept. State Cab., p. 78, 1859.

Rhynchonella neglecta; Meek; Pal. Ohio, Vol. I., p. 179, pl. 15, fig. 3.

Cavities left by the removal of the shells of this species by solution, and showing the impression of the exterior surface and characters, are common in some specimens of limestone examined from the Niagara formation at Cedarville, Greene county, Ohio. Casts made with gutta-percha in these cavities furnish the following features, which agree precisely with specimens from the Niagara shales of New York:

Shell small, seldom measuring three-eighths of an inch in their greatest diameter; form sub-triangular, or triangularly ovate; broadest in front, with a small, sharp, slightly incurved beak; distance across the valves from side to side much greater than the dorso-ventral diameter; front of valves rounded. Dorsal valve a little the most convex, somewhat regularly arcuate from beak to front; sides more strongly rounded; ventral valve having the sides somewhat angular from the abrupt depression of the mesial sinus.

Surface marked by about twelve sharp, angular plications, of which there are three in the sinus and usually four on the mesial elevation. Surface markings on the plications not preserved, owing to the unfavorable condition of preservation.

Formation and locality: In the Niagara group, at Cedarville, Greene county, Ohio. State collection. Collected by Prof. E. Orton.

* See observations on this species under *R. scobina*.

RHYNCHONELLA PISA (n. sp.).

Plate 7, figs. 18-22.

Shell small, globular in full-grown specimens, but varying from depressed lenticular to highly gibbous at different stages of growth. General outline of the shell broadly ovate, widest near the front or below the middle of the length. Ventral valve less gibbous than the dorsal; beak small, pointed, and slightly curved, usually projecting but moderately beyond that of the opposite valve, though sometimes rather extended; body and sides of the valve regularly rounded, becoming broadly, but not deeply, sinuate in front, where it is prolonged and bent upward in the middle. Dorsal valve regularly convex, the center of the valve the most prominent, becoming slightly elevated in front, forming a not very prominent mesial elevation.

Surface marked by from twelve to sixteen rounded plications, which are distinctly marked on the sides and in front, but become obsolete soon after reaching the middle of the valve on the dorsal side, but are continued somewhat further on the ventral, and in some specimens those bordering the sinus extend to near the beak. On the dorsal valve there are usually four plications elevated to form the mesial fold, and three depressed in the ventral sinus, though in some cases there are only three elevated on the dorsal valve.

The species resembles *R. neglecta*, with which it is associated, but differs in the general convexity of the valves and want of angularity in the plications, which do not extend to the beak, as in that species. The more elongate forms resemble *R. acinus*, Hall, but have not the flattening of the sides and surfaces of the valves, as in that species, and have, moreover, a greater number of plications. The more ventricose forms resemble very closely small specimens of *R. nucleolata*, Hall, but, besides being more elongate, with a more projecting beak, the plications are never flattened on their surfaces, and are destitute of the groove along the middle, as in that one.

Formation and locality: In the limestones of the Niagara group, near Danville and Sinking Springs, Highland county, Ohio. State Collection. Collected by Prof. Edward Orton.

RHYNCHONELLA TENNESSEENSIS.

Plate 7, figs. 16, 17.

Rhynchonella Tennesseeensis, Roemer; Sil. Fauna West. Tenn., p. 72, pl. 6, fig. 14.*Rhynchonella Tennesseeensis*, Hall.

Shell rather above the medium size, sub-circular or sub-triangular in outline in a dorsal or ventral aspect, somewhat rounded at the beaks in the cast, the condition in which it is mostly found in Ohio, and broadly truncate in front, the cardinal margins being rounded to the widest part of the shell, which is near the front of the valves. Dorsal valve very highly convex, rapidly rising from the beak to the front of the shell, along the center, but as rapidly sloping on the lateral portions from the middle of its length to the antero-lateral angles; center of the valve somewhat abruptly elevated forward of the middle, in some cases forming the mesial elevation. Ventral valve shallow on the rostral and lateral portions, very broadly and deeply sinuate in the middle, the depression occupying much the greater part of the breadth of the valve; front strongly elevated, and prolonged in a broad linguiform extension, fitting into and conforming to the elevation of the dorsal valve.

Surface of the shell marked by from fourteen to twenty simple, strong, angular plications, six to eight of which are elevated on the dorsal valve, forming the mesial fold, and a corresponding number depressed on the ventral valve to form the broad, shallow sinus.

The specimens obtained from Ohio being in the condition of internal casts, the rostral portion of the specimens is shortened by the removal of the shell, which is much thickened in this part, and instead of the pointed beaks of the perfect shell, shows the reverse of the hinge characters, and the form of the muscular impressions. This latter feature is large on the ventral side, giving an elongate ovate elevation on the postero-central region of the cast. On the dorsal side the impressions are faintly marked, and are often distinguished on this valve only by the interruption of the plications on this part of the surface; near the center of the hinge are seen the impressions of the teeth and socket lamellæ.

The species is readily distinguished by the broad, sub-triangular form, and coarsely plicated surface, together with the broad sinus and elevation, especially as seen in a front view.

Formation and locality: In the limestones of the Niagara group, at Yellow Springs, Ohio. Collection of Prof. Hall, and Ohio State collection. Collected by Prof. Edward Orton.

GENUS PENTAMERUS, Sowerby.

PENTAMERUS OBLONGUS, Sowerby.

Plate 7, fig. 9.

Pentamerus oblongus, Sow.; In Murch. Silurian Syst., p. 641, pl. 19, fig. 10.*Pentamerus oblongus*, Hall; Pal. N. Y., Vol. II., p. 79, pls. 25 and 26.*Pentamerus bisinuatus*, McChesney; New Pal. Foss., p. 55, 1859; also re-issue in Trans.

Acad. Nat. Sci., Chicago, Vol. I., pl. 9, fig. 1.

Pentamerus oblongus, Authors.

Shell large, elongate ovate in outline, broadest below the center, often lobed, and not unfrequently indistinctly plicated in the forward portion. Valves depressed convex in the younger and medium sized specimens, becoming ventricose, gibbous, or even inflated, in older or larger individuals; the sides of the valves in the upper portion, but below the cardinal margins, flattened or concave, sometimes forming a shallow groove extending from below the beaks of each valve and reaching nearly to the widest, or largest, part of the shell. This feature is not seen during the very young stages of growth. Front margin of the valves strongly constricted or lobed by depressions of the surface, which extend from the margin to a greater or less distance toward the rostral portion of the shell on each valve. Ventral valve much deeper than the dorsal, especially in the more ventricose forms, with a strong, projecting, moderately incurved beak, beneath which is a broad, triangular fissure; lateral margins of the beak sub-angular. Dorsal valve less ventricose, most prominent on the upper third of the length; beak small, closely incurved.

Surface of the valves smooth or distinctly plicated, and marked by frequent, strong, concentric lines of growth at irregular distances.

The internal casts of this species, the condition in which they are usually found in Ohio, has the beak of the larger valve strongly and deeply divided down the center, to about one-third of the entire length, by the removal of the longitudinal septum, which has supported the broad, spoon-shaped process beneath the beak, the filling of which is seen occupying the space between this portion of the valves. The dorsal valve is also divided longitudinally by two slits, caused by the removal of the septa that has characterized this valve. These slits frequently extend nearly, or quite, to the middle of the valve, but are placed very near to each other, diverging very gradually as they recede from the beak.

This very variable species is so common and so well known that an extended description is unnecessary. It has been described under several names, indicating varieties or phases, most of which can be found at almost any locality where it occurs abundantly, and where the circumstances of life have been favorable to its development. The surface characters are extremely variable, being smooth or variously plicated over a portion only, or over the entire surface, the plications extending only to a short distance from the front margin, or nearly or quite to the rostral portion of the valve, sometimes finely marked, and, again, having low, broad, and rounded ribs. The strength of the lobing or constrictions of the valves may be either faint or strongly marked, and not uncommonly entirely obsolete. These several changes, however, are only individual differences, and of no specific importance.

Formation and locality: In the limestones of the Niagara group, at Yellow Springs, Ohio. The species has a very wide geographical range, and is known in New York, Ohio, Canada, Illinois, Wisconsin, and Iowa, as well as in many parts of Europe.

PENTAMERUS (PENTAMERELLA) VENTRICOSUS.

Plate 7, figs. 7, 8.

Pentamerus ventricosus, Hall; Geol. Rept. Prog. Wis., 1860, p. 2.

Pentamerus (Pentamerella) ventricosus, Hall; 20th Rept. State Cab., p. 374, pl. 13, figs. 18-21.

Shell small globose, wider than long; hinge line short, and abruptly rounded at the sides. Ventral valve much the most convex, with strongly incurved beak and prominent umbo, the middle of the valve marked by a broad, deeply depressed sinus, extending from the beak to the front margin of the valve; front of the valve prolonged, and strongly bent upward into a broad, linguiform extension. Dorsal valve prominent on the umbo; beak small and incurved; center of the valve toward the front sharply elevated, forming a narrow mesial elevation extending about half way to the beak; on the sides of the fold the surface is depressed, forming a sinus on each side, and giving a strongly trilobed character to the front of the shell.

Surface of the shell marked by concentric undulations of growth, visible on the internal casts. Median septum of the ventral valve short, not conspicuous.

All the examples of this species seen, from localities in Ohio, are of rather smaller size than those from the more western and typical locali-

ties, and show no evidence of radiating striæ or obscure plications, as is sometimes the case on those just referred to. The species is readily distinguished from others associated with it by its small, round, or globose form, and the trilobed front of the valves. It differs from the ordinary forms of *Pentamerus* in having the middle of the dorsal valve elevated in the form of a mesial fold, while in true *Pentamerus* it is depressed, forming a sinus on this side, with a corresponding elevation on the larger or ventral valve.

Formation and locality: In limestones of the Niagara group, at Yellow Springs, Ohio. Collected by Prof. E. Orton. In collections of Columbia College and Prof. James Hall, and Ohio State Collection.

PENTAMERUS PERGIBBOSUS (n. sp.)

Plate 7, figs. 10, 11.

Shell of medium size, extremely and extravagantly gibbous; proportionally very elongate from beak to base, and very narrow, the greatest width being near the front, and equal to only about two-thirds the depth of the two valves when united in the broader specimens, and in some extravagant cases not more than one-third as wide, while the depth of the united valves more than equals the length of the dorsal valve. Beaks distant, strongly incurved, that of the ventral valve the most prominent and narrower than the opposite. Ventral valve about twice as deep as the dorsal; most prominent and ventricose about one-third of its length from the beak; somewhat gradually sloping from this point to the front margin; triangular foramen large, higher than wide, partially filled by the beak of the opposite valve. Dorsal valve more regularly arcuate than the ventral—almost evenly so, except for the constrictions of the surface by strong lines of growth; beak wide, strongly incurved to the foramen of the ventral valve. Surface of the internal casts (the condition in which the specimens occur) strongly constricted by concentric lines, marking stages of growth, but placed at irregular distances, and often dividing the surface into several strongly marked transverse lobes.

The interior of the shell has been characterized by large longitudinal septa, as seen by the cavities left in the casts; that of the ventral valve extending fully to or beyond the middle of its length, while those of the dorsal valve reach about two-thirds of the length of the valve, in all the specimens examined; and in one example almost to the front margin, and vertically to the entire depth of the valve.

The surface of the shell in its original condition has been marked by fine radiating striæ, which are still visible on the casts of some individuals near the front of the valves, although the most of them appear to be smooth, except for the concentric constrictions.

This species is probably most nearly related to *P. occidentalis*, Hall, from the Onondaga salt group, Galt, Canada West; it differs, however, very materially from that one in the much greater depth of the dorsal valve, and also in the relative thickness of the longitudinal septa—that one having them very thick and strong, and in the finer striations of the surface. From *P. Littoni*, Hall, another closely allied species, it differs in being more extravagantly gibbous and narrower, and in being more finely striated.

The species has been referred to *P. ventricosus*, Hall, but the dissimilarity is so great that a comparison of the figures of the two species on the plate will not fail to strike the most casual observer.

Formation and locality: In the Niagara group, at Greenfield, Darke county, Ohio. Collected by Rev. Mr. Hertzner.

LAMELLIBRANCHIATA.

GENUS AMPHICELIA, Hall.

(Extr. 20th Rept. State Cab., 1865; 20th Rept. State Cab., p. 339.)

AMPHICELIA (LEPTODOMUS ?) COSTATA (n. sp.).

Plate 7, fig. 23.

Shell of medium size for the genus, broadly triangular ovate, with prominent projecting beaks, which are strong, pointed, slightly incurved, and nearly terminal. Valves very ventricose and inflated in the anterior portion, gradually declining to the posterior margin, giving a broadly cuneiform cardinal profile; hinge line straight, about half as long as the shell, abruptly bent nearly at right angles beneath the beaks. Anterior end regularly and broadly rounded from below the hinge to the basal margin, which is more broadly rounded toward the posterior portion; posterior extremity obtusely pointed at the place of the greatest length, which is about midway between the hinge line and the base of the shell. From the obtuse posterior point to the extremity of the hinge the margin is abruptly sloping, with a moderate degree of curvature. In a cardinal view the anterior end of the united valves appears to be almost

squarely truncate, owing to the abruptly declining anterior portion of the valves below the inflated umbonal region.

Surface of the valves marked by moderately strong radiating costæ, about seven or eight of which occupy the space of half an inch, measured near the middle of the basal border on the larger specimen. The costæ appear to have been low, rounded, simple, and with exceedingly narrow interspaces. As far as can be determined from the specimens in their condition as casts, the costæ have been strongest on the middle of the shell, becoming gradually finer toward the posterior portion of the valves.

Beneath the beaks in the casts is preserved the remains of what appears to have been the filling of a rather large, double depression in the hinge plate of each valve, which may have been the cavity for the reception of an internal ligament; or it may have been a tooth and ligamental cavity in one, and tooth cavity and ligament in the other. This feature has been observed in several specimens of other species, but has always been a little obscure. If specimens were collected with a little care, and examined in connection with the matrix, this question could be readily determined. One of the individuals of this species examined shows evidence of an anterior and posterior muscular imprint of medium size; the former situated near the anterior border of the shell, about half way between the beaks and the basal line, the other just within the margin of the shell, below the extremity of the hinge line—the two being connected by a distinct and entire pallial line.

Formation and locality: In limestones of the Niagara group, near the upper portion of the formation (Guelph horizon), at Cedarville, Greene county, Ohio. Ohio State collection. Collected by Prof. E. Orton.

GASTEROPODA.

GENUS SUBULITES (Hall), Conrad.

(Pal. N. Y., Vol. I., p. 182, 1847.)

SUBULITES TEREBRIFORMIS (n. sp.).

Plate 8, fig. 6.

Shell of moderate size, elongate terebriform, spire not regularly tapering, but very slightly swelling along the middle to the center of the body volution, from which point it is again contracted to the lower extremity. Spire consisting of four or five volutions, the last or body volu-

tion forming nearly two-thirds of the entire length of the shell. Aperture elongate, narrow, acutely pointed above and broad below, forming more than one-half of the length of the body volution. Suture faintly marked and close. Surface apparently smooth.

The species differs from *S. ventricosa*, Hall, from the Onondaga salt group of New York, and also from the Niagara formations of Wisconsin, in being much more slender in proportion to its length, as well as being a much longer shell; also, in having the spire erect instead of bent to one side, as in that species, and in having the volutions more rapidly increasing in length. From *S. elongatus*, Conr., of the Trenton limestone, it differs in being proportionally shorter in the spire as compared with the body volution, and not so regularly tapering, the whole being rounded toward the apex. It is, however, so closely related in form to that species that it is exceedingly difficult to draw a very satisfactory comparison. This species is the first one noticed in rocks of this age in this country, so far as we are aware, that has not the spire bent on one side like that of *S. ventricosa*.

Formation and locality: In the limestones of the Niagara group (upper part, or Guelph horizon), at Clifton, Greene county, Ohio. State collection. Collected by Prof. E. Orton.

GENUS PLEUROTOMARIA, DeFrance.

PLEUROTOMARIA OCCIDENS.

Plate 8, fig. 2.

Pleurotomaria occidens, Hall; 20th Rept. State Cab., pp. 342 and 364, pl. 15, figs. 11, 12; 2d Ed., p. 392, pl. 15, figs. 11, 12, and pl. 25, figs. 9, 10.

Shell rather large, depressed; consisting of from two to three rapidly enlarging volutions. Spire low, not equaling one-half the height of the shell. Volutions flattened on the upper side; strongly carinate and banded on the periphery, and regularly rounded below, except near the aperture of the finished shell, where it becomes prolonged or extended downward in the middle. Umbilical region broadly impressed, but not perforate, the surrounding surface gradually rounding into the cavity. Columellar lip thickened, forming a callous over the umbilicus; reflected and curved in the lower part. Aperture large, sub-triangular, somewhat transverse in the specimen; prolonged and pointed in the lower lateral portion.

Surface of the shell marked on the upper surface of the volutions by

strong revolving lines or ridges, and apparently by transverse lines, and on the lower side by revolving ridges crossed by concentric lines of growth parallel to the margin of the aperture. Apertural notch not fully determined.

The shell differs somewhat from those from the more western localities in Wisconsin and Iowa, especially in the greater flattening of the volutions, and in the more strongly carinate and less distinctly banded periphery. But these features may be due in part to the vertical compression to which the specimen has been subjected. The species is closely related to *P. labrosa*, Hall, from the Lower Helderberg group of New York, but differs in the smaller depth of the volution below the periphery.

Formation and locality: In the limestones of the Niagara group, at Yellow Springs, Ohio. Collected by Prof. E. Orton.

GENUS TROCHONEMA, J. W. Salter.

TROCHONEMA PAUPER ?.

Plate 8, fig. 4.

Comp. *Pleurotomaria pauper*, Hall; Extr. 20th Rept. State Cab., p. 343, 1865.

Comp. *Trochonema (Pleurotomaria) pauper*; 20th Rept. State Cab., Expl. pl. 15, figs. 5, 6, and 9.

Shell of medium size, broadly turbinate, consisting of three or more rounded ventricose and moderately increasing volutions. Suture line deeply marked and distinct, giving to the exposed portion of the volution a full, round, almost inflated character. Form of the inner lip of the aperture and umbilicus unknown from Ohio specimens.

Surface of the volutions marked by numerous distinct revolving bands, with concave spaces between them; about twelve of these bands can be counted on the exposed part of the last volution, which extends to near the lowest point as preserved in the rock. Between some of the more distant bands, and near the largest part of the volution, there are faint traces of intermediate bands of smaller size. There are also fine, closely crowded concentric striæ of growth marking the surface and crossing the volution with a strong backward direction from the suture line toward the base of the shell, which undulate but very slightly as they cross the revolving bands. On the upper volutions the revolving bands are sharper, and the spaces between narrower and more deeply concave.

There may be some question concerning the specific relations of this

shell. So far as can be seen from the only imperfect impression examined, it differs somewhat from the original specimens of the species in the more rapid increase of the volutions, and also in the greater number of revolving lines or bands; and no specimens have been seen that will satisfactorily determine the characters of the umbilical region. It is possible, therefore, that it may yet prove to be an entirely distinct species when better specimens are examined. We, therefore, propose to consider it as a variety of the above species under the varietal name of *Ohioensis*=*Trochonema pauper* var. *Ohioensis*.

Formation and locality: In the upper part of the Niagara group (Guelph horizon), Greenville, Ohio. From the Ohio State collection. Collected by Rev. H. Hertzner.

GENUS STRAPAROLLUS, Montfort.

STRAPAROLLUS NIAGARENSIS (n. sp.).

Plate 8, fig. 3.

Shell small, discoidal, consisting of from two to two and a half volutions in a specimen measuring one inch and three-tenths in its greatest diameter. Volutions moderately increasing in size, and contiguous to each other, circular in a transverse section, the internal cast showing a space between the filling of two volutions equal to one-sixteenth of an inch, to allow for the thickness of the two walls of shell removed. Spire flat, or having the inner volutions slightly depressed below the plane of the outer one. Umbilical side broad and shallow, but more deeply depressed than the spire, exposing almost the entire diameter of the inner volutions, and in the cast showing the entire diameter.

The surface of the shell, judging from the cast, has been marked by six or more faint, revolving lines or carinæ. The two principal and most central ones form a band on the periphery, below which there are three others, and one or two additional ones below. There are also remains of strong, irregular, concentric lines of growth crossing the volutions.

The species is represented only by internal casts, and in this condition bears a striking resemblance to shells of *Euomphalus* (*Straparollus*) *laxus* and *E. (?) noveboracensis*, Hall, the volutions having nearly the distance from each other as those of that species which retain the shell; but if due allowance is made for the thickness of the two shell walls, it will be found that in this species they have been in close contact. In this respect it corresponds more nearly with *Euomphalus clymenoides*, Hall, from the Schoharie grit of New York, from which it differs in the more rapid

increase of size in the volutions. It differs from *S. mopsus*, Hall, from the Niagara group of Wisconsin, in the smaller number of more rapidly enlarging volutions, in the revolving ridges of the surface, and in the more depressed spire.

Formation and locality: In the upper part of the Niagara group, at Cedarville, Ohio. Collected by Rev. H. Hertzner.

GENUS TREMANOTUS, Hall.

(20th Rept. State Cab., p. 347.)

TREMANOTUS ALPHEUS.

Plate 8, fig. 1.

Tremanotus Alpheus, Hall; Extr. in Advance of the 20th Rept. State Cab., 1865, p. 43.

Tremanotus Alpheus, Hall; 20th Rept. State Cab., p. 347, pl. 15, figs. 23 and 24.

Bucania (Tremanotus) perforatus, Winch. and Marcy; Enumeration of Foss. collected in the Niagara Limestones near Chicago, etc., p. 100, pl. 3, fig. 7.

Bucania Chicagoensis, McChesney (in part); Expl. of pl. 8, fig. 4, Pal. Foss., 1865.

An example of this species, possessing all the features, as far as the imperfect condition of the specimen will permit of identification, has been obtained from the limestones of the Niagara group, of Genoa, Ohio. The example shows the shell to have been composed of two or more volutions, which are broad and flattened, their lateral diameter being nearly double that of the dorso-ventral diameter, the outer volution embracing the inner one, as seen on the internal cast, to the extent of a little less than one-half their diameter, leaving a broad, open umbilicus. Volutions broadly rounded on the back, and sharply rounded on the lateral portions. The aperture is not preserved on the specimen under consideration; that of the species, however, is broadly expanded. The middle or dorsal portion of the outer volution is marked by a number of elongated projections, their long diameter corresponding with the plane of the volution, indicating the dorsal perforations characteristic of the genus. Seven of these projections can be counted on a little less than half of the outer volution.

The surface of the cast is smooth, there being no evidence of the external revolving ridges which characterizes the exterior of the shell on the typical specimens. These, however, are frequently not preserved on the internal casts from the original locality.

Formation and locality: In the limestones of the Niagara group, at Genoa and Springfield, Ohio. Collections of Columbia College and of Prof. Edward Orton.

TREMANOTUS? TRIGONOSTOMA (n. sp.).

Plate 8, fig. 5.

Shell moderately large, consisting of two or more volutions, the last one broadly expanded, forming a broadly sub-triangular lip bordering the aperture, the margins of which extend at right angles to the plane of the shell, on all sides, to a distance equal to the extent of the preceding volution, as seen on the posterior side of the aperture, except on the front or dorsal border, where it is directed upward, corresponding to the carinate front of the volution, and deeply sinuate, forming a broad, triangular notch. Inner volutions rounded on the back, and somewhat modified on the inner face by those within. Umbilicus apparently broad and deep. Surface smooth, not ribbed or costate, as is shown by the impression of the exterior surface in the rock.

The specimen used for description is a cast partly of the interior and partly of the exterior. It has a broadly expanded body volution and protruded front, which characterizes the genus *Tremantotus*, but the specimen is not perfect enough to show the perforations on the dorsal portion of the last volution. The inside of the aperture is sub-triangular, the inner lip forming a straight margin across this side, which is scarcely modified in the center by the preceding volution, the outer margin of the lip on this side overlapping the inner whorl, and extending backward as far as the extent of the whorl.

It is possible that the species may prove to belong to the genus *Bucania*, but the evidence is rather in favor of the other determination. It differs from *T. alpheus*, Hall, in the smooth surface, that one having strong ribs or costæ marking the outer volution; also in the triangular form of the aperture.

Formation and locality: In the limestones of the Niagara group, at Genoa, Ohio. From the collection of Columbia College, New York.

CEPHALOPODA.

GENUS ORTHOCERAS, Breyn.

ORTHOCERAS ANNULATUM.

Plate 9, fig. 1.

Orthoceras annulatum, Sow. : M. C., tab. 133, 1818.*Orthoceratites undulatus*, Hisinger; Anteckn. V., tab. 4, fig. 6; Vet. Akad. Handlingar, tab. 7, fig. 8.*Orthoceratites undulatus*; Lethea Suecica, p. 28, tab. 10, fig. 2, 1827.*Orthoceras annulatum*; Murch. Silurian Syst. and Siluria.*Orthoceras undulatum*; Pal. N. Y., Vol. II., p. 293, pls. 64 and 65.*Orthoceras annulatum*, Hall; 20th Rept. State Cab., p. 351.*Orthoceras nodocostatum*, McChesney; New Pal. Foss., p. 94.*Orthoceras nodocostatum*; Trans. Chicago Acad. Sci., Vol. I., p. 53, pl. 9, fig. 5.*Orthoceras Laphami*, McChesney; New Pal. Foss., p. 91.

Specimens of this species appear to be not uncommon at several localities of the Niagara group in Ohio, and frequently present the features of the species in a very good state of preservation. The individuals which have been received for examination range from a diameter of one inch and three-eighths to over two inches and a half. The shell is very gradually expanding from below upward, appearing in examples of a few inches in length to be of nearly or equal size at the opposite ends, very broadly oval in a transverse section, and strongly annulated by concentric rings, which are more advanced on the sides of the shell in the direction of the longest diameter than on those of the opposite or shorter diameter. Annulations sharply elevated, and rounded on the top, where the substance of the shell is preserved, with broad, deep, concave depressions between them; but where the specimens consist entirely of internal casts of the shell the rings and depressions are much less distinct. The distance of the annulations from each other varies somewhat with the size of the shell, but is not uniform in the different individuals. On a fragment of an inch and a half in diameter the annulations are three-eighths of an inch from crest to crest, giving eight ridges and eight spaces in a length of three inches; and on another individual, where the diameter is two and a half inches, the same number of rings measure three and a quarter inches only, the difference between the two being scarcely perceptible. Septa deeply and regularly concave, their edges corresponding to the external annulations in distance, the ridge of the annulation being placed at or a little in advance of the middle of the

chamber, and the edges of the septa, in the direction of the longest diameter of the shell, being as much in advance of those on the flattened sides as will correspond with the increased diameter of the tube in that direction.

Surface of the shell marked by closely arranged, concentric lines of growth, which are strongly undulated and lamellose, but less distinctly marked on the ridges than between. There are also distant parallel ridges traversing the shell longitudinally, and forming slight nodes where they cross the concentric annulations. The surface characters, especially the longitudinal ridges, are often quite obscure, and where the specimens are casts of the interior, the lamellose lines are seldom, if ever, seen, although the nodes left by the ridges, where they cross the annulations, are in these cases frequently quite distinct.

The species has been so frequently described, and is so universally known, that it is not necessary to institute comparisons between the several forms which have given rise to the many synonyms under which it has appeared.

Formation and locality: In the limestones of the Niagara group, at Yellow Springs, Cedarville, and elsewhere in Ohio.

ORTHOCERAS CREBESCENS.

Plate 9, fig. 2.

Orthoceras crebescens, Hall; 20th Rept. State Cab., p. 354, pl. 19, figs. 1-3.

Shell of rather large size, gradually and moderately tapering; transverse section circular, or sub-circular, from compression; septa deeply and evenly concave, quite regularly disposed and distant, about three and a half of the chambers occupying a length equal to the diameter of the shell where counted; siphuncle very large, and centrally situated; surface unknown.

The examples, being all internal casts, do not preserve the features of the exterior surface, but that of the casts is perfectly smooth, so far as can be determined. There are some points of difference between the Ohio specimens and those from the more western localities from which the original description of the species was taken, as the slightly greater distance of the septa, and the more distinctly oval form of the shell. This latter feature, however, may have been caused to considerable extent by compression, as all of the individuals observed have the flattening in the direction of the plane of the strata, as far as can be deter-

mined from the filling of the chambers and the adhering rock. These differences, being so slight, have not been deemed of sufficient importance to require a distinct specific designation.

Formation and locality: In the limestones of the Niagara group, at Cedarville, Greene county, Ohio. Collected by Rev. H. Hertzner.

ORTHOCERAS STRIX (n. sp.).

Plate 9, fig. 3.

Shell rather large, somewhat rapidly expanding from below upward, increasing from a diameter of one and a quarter inches to exactly twice that diameter in a length of seven inches; transverse section broadly oval, or sub-circular, the greater flattening of some examples having been caused partly by compression, as is shown by the more nearly circular form of the lower extremity of the specimen figured. Septa strong, moderately concave, and widely separated, being a little more than half an inch distant from each other in the examples studied, and the distance apparently not increasing with the increase of the shell. Siphuncle sub-central, proportionally not very large. Surface of the cast marked by strong, longitudinal flutings, which measure nearly or quite half an inch from crest to crest at the upper end of the specimen figured, and a little more than a fourth of an inch at the lower extremity of the fragment; interspaces regularly concave. The surface of the shell has apparently been longitudinally striated in the flutings, as is shown by a fragment of shell adhering to the cast in the depression of one of the flutings, but no evidence of transverse striæ, like that on some species of this group, has been seen.

This species bears considerable resemblance to *O. columnare*, Hall, but besides having the flutings of much larger size in comparison, the shell tapers much more rapidly than any of the forms referred to that species. Compared with *O. cadmus*, Bill, Sil. Foss. Anticosti, p. 83, it differs very materially in the more rapid increase in size, and in its oval section.

Formation and locality: In limestones of the Niagara group, at Yellow Springs, Ohio. Collected by Prof. Edward Orton.

GENUS CYRTOCERAS, Goldf.

CRYPTOCERAS MYRICE (n. sp.).

Plate 8, fig. 9.

Shell rather below the medium size, very moderately expanding from below upwards, but a little more rapidly below than above the middle of the length; a slight constriction just below the margin of the aperture

forms a broad, shallow depression around the shell at this point. Curvature of the shell very moderate throughout the entire length, the arc of the inner side deviating but little from a straight line, while the curvature of the outside is greater by the increased diameter of the shell; transverse section nearly circular, a very little flattened in the dorso-ventral direction, which may be partly due to compression. Septa numerous, rather closely arranged, measuring about six in the lower part, and over eight in the upper part, in a distance equal to the diameter of the shell at the top of those included in the measurement. Position of the siphuncle not observed.

Surface of the cast longitudinally fluted, and yet, more distinctly on the fragments, preserving the shell partially exfoliated or eroded. The flutings consist of sharp, elevated ridges, with regularly concave interspaces. On the body of the shell the ridges are a little more than a line apart from crest to crest, numbering twenty-seven in the circumference of the shell.

The species is entirely unlike any other form of the genus yet described from rocks of this age, in the slight curvature and lirated surface, combined with the circular section.

Formation and locality: In limestones of the Niagara group, at Yellow Springs, Ohio. Ohio State collection, and collection of Columbia College, New York.

CRYPTOCERAS HERTZERI (n. sp.).

Plate 8, figs. 7, 8.

Shell of medium size, moderately arcuate, and rather rapidly expanding to the outer chamber; broadly ovate transversely, the largest on the outer side of the center, the two diameters being as eleven to thirteen. Outer chamber short, rapidly contracting above, and rounded to the constrictions of the aperture; the height being somewhat less than the smallest transverse diameter, the point of greatest elevation being near the dorsal side of the aperture, whence the surface slopes rapidly, but with some convexity, to the inner side of the shell. Aperture deeply lobed, the dorsal portion first forming four lobes, two on each side of the center, the inner ones afterwards becoming again divided, giving three lobes to each side of the median line, with a deep median sinus dividing the two sets on the dorsal margin. The inner or ventral portion of the aperture forms an elongate ovate opening, connected by a narrow slit with the dorsal lobes, and reaching to nearly one-third of the distance

between the dorsal extremity of the aperture and the first septum on the inner side of the shell; the entire length of the aperture is equal to about six-sevenths of the shortest diameter of the largest part of the shell. Septa rather closely arranged, slightly concave, and strongly arching upwards on the back, each of them, except that next the outer chamber, marked near the upper margin, as seen in the portion of a cast figured, by an impressed line to near the inner side, where it becomes deflected from the direction of the septum, and crosses to its lower limits.

On the surface of the cast are seen distinctly depressed lines running lengthwise, and corresponding to the curvature of the shell, giving evidence of the exterior surface having been faintly lirated, or longitudinally fluted. Siphuncle small, situated about twice its diameter from the inner margins of the septa.

This species has its nearest analogue in *C. septoris*=*Gomphoceras septoris*, Hall, 18th Rept. State Cab., p. 350, but differs in the greater length of the outer chamber, in the form and proportion of the lobes of the aperture, in the more lateral position of the opening, and in the rounding or sloping of the ventral side of the outer chamber. The dorsal lobes of the aperture in that species are seven, one being central and the other three pairs gradually lessening in size towards the ventral side, while in this there is no central one, and each of the others are of nearly the same lateral extent.

Formation and locality: In the limestones of the upper part of the Niagara group (Guelph horizon), at Cedarville, Greene county, Ohio. Ohio State collection. Collected by Rev. H. Hertzner.

GENUS PHRAGMOCERAS, Broderip.

PHRAGMOCERAS PARVUM (n. sp.).

Plate 8, fig. 10.

Shell small, strongly curved, and rapidly expanding toward the outer chamber; transversely broadly ovate below, but becoming more flattened toward the aperture; widest on the dorsal side of the center, and rounded on the back, the inner side narrow, and almost sub-angular. Outer chamber about as long as the dorso-ventral diameter of the shell at the upper margin of the last septum; edges of the aperture sharply inflected toward each other, contracting the opening to a narrow slit along the middle of its length, which terminates in a rounded triangular opening at the dorsal end, the margins of which are slightly raised; and at the

ventral end it is prolonged into a tube-like projection, extending to a distance beyond the limits of the shell below, about equal to one-fourth of the lateral diameter of the outer chamber at its widest part. The septa, only two of which are preserved in the specimen figured, are proportionally distant, slightly concave, and but little curving upwards at the dorsal and ventral portions. Siphuncle minute, situated close to the inner margin. Exterior surface unknown.

The species differs from any other described in its small size, in the general form and rapid curvature, combined with the protruding tube-like process at the ventral extremity of the aperture.

Formation and locality: In the limestones of the upper part of the Niagara group, at Cedarville, Greene county, Ohio. Ohio State collection. Collected by Prof. E. Orton.

PHRAGMOCERAS ELLIPTICUM (n. sp.).

Plate 8, fig. 11.

Shell of large size, slightly curved, transverse section narrowly elliptical, a very little wider on the outer than on the inner side of the center. Outer chamber wider than high; very depressed convex on the sides, and sharply rounded on the dorsal and ventral edges; the ventral side extended at the aperture, forming a tube-like projection; the remainder of the aperture not known. First chamber below the chamber of habitation very shallow; septa deeply concave; siphuncle large, situated close to the inner side of the shell.

The specimen used in description consists of the cast of only the outer chamber and a fragment of the filling of the next chamber below, and is, moreover, imperfect at the upper extremity; but the form of the transverse section is so very distinct from any other species yet described that it is readily characterized, and as readily distinguished from any other species. The shell has been of very large size, the fragment used measuring nearly four inches in width, with a height of three and a quarter inches, the thickness from side to side being only a little more than one and a half inches. The peculiar narrow form of the transverse section is a good distinguishing feature.

Formation and locality: In the limestones of the Niagara group, in Highland county, Ohio, associated with *Trimerella Ohioensis*. Ohio State collection. Collected by Prof. Edward Orton.

CRUSTACEA.

GENUS CALYMENE, Brong.

CALYMENE NIAGARENSIS.

Plate 7, figs. 14, 15.

Calymene Niagarensis, Hall; Geol. Rept. 4th Dist. N. Y., 1843, p. 102, and fig. 3, p. 101.*Calymene Blumenbachii*, var. *Niagarensis*, Hall; Pal. N. Y., Vol. II., p. 307, pl. 67, figs. 11 and 12.

General form elongate obovate, widest at the posterior limit of the cephalic shield, gradually tapering from this point to the anterior border of the pygidium, beyond which it tapers more abruptly. Cephalic shield short and broad, the width twice and a half as great as the length. Glabella very prominent, projecting above the cheeks and eyes; rounded and full in the center and front; separated from the fixed cheeks by deep, sharp furrows; the general form conical, rounded truncate anteriorly, widest across the posterior lobes, which is equal to the length, including the occipital ring, strongly divided by transverse furrows, and showing in the cast, in which condition it is usually found, four pairs of lateral lobes—the two anterior ones narrow and faintly marked, the third small, but rounded end node-like; the posterior lobes large, having the form of rounded tubercles. Occipital groove narrow and arching forward in the middle. Anterior border of the head narrow, and abruptly curving upward in the middle. Eyes small and prominent. Posterior limb of the fixed cheeks broad and extending to the postero-lateral angles of the head. Suture line reaching the anterior border of the head directly in front of the eye, and forming nearly a straight line between these points; behind the eye it is directed toward the postero-lateral angles of the head with a regular forward curve.

Thorax consisting of thirteen articulations, the length about twice and a half as long as the entire length of the head, measuring along the axial lobe; strongly trilobate longitudinally; the central lobe forming a little more than one-third of the entire breadth, elevated above the lateral lobes, and highly arched transversely, separated from the lateral lobes by a sharply marked longitudinal furrow. Lateral lobes flattened on the top for nearly or quite one-third of their width, then more or less abruptly curving downwards to the extremities of the pleura. The articulations are distinctly arched forward along the center of the axial lobe, and each one is marked in the cast, on each side of the axis, near its junction with the lateral lobes, by a distinct, rounded, more or less

prominent tubercle or node. Pleura marked by a broad, deep furrow, rising from the upper edge near the axis and extending more than two-thirds of the length, terminating on the expanded overlapping portion in a narrow, curving line. On the upper part of the lateral lobe the furrow occupies fully one-half the width of the rib.

Pygidium sub-triangular in outline, about as long as the length of the glabella, exclusive of the occipital ring; its length along the centre about equal to each lateral face, measuring from the antero-lateral angle to the posterior extremity, the lateral lobes being much wider than the axial. Axis obconical, longer than wide, obtusely rounded at the extremity, and not reaching to the border of the plate; marked by six or seven articulations, exclusive of the terminal one. Lateral lobes rounded or sloped on the anterior border, the surface abruptly declining from the longitudinal furrow to the lateral margins; border broad and thickened, the four or five articulations extending but little more than half way to the edge of the plate, and not showing any evidence of a central depression. Posterior border of the pygidium broadly notched on the lower edge, not showing except in a posterior view.

As the specimens obtained in Ohio are always in the condition of internal casts, the characters are, of course, somewhat different from those seen where the substance of the crust is preserved. The species has a very wide geographical range, occurring in nearly all localities of the Niagara formation throughout the country, but usually in the condition of casts in the dolomites of the West. It bears considerable resemblance to *C. senaria*, Conrad, from the lower geological formations, but differs in several minor points. The most noticeable, and one which readily serves to distinguish the two forms, is the much greater projection of the anterior rim of the head, and its more strongly upward curvature in that species.

Formation and locality: In the limestones of the Niagara group, at Cedarville, and more commonly at Eaton and Yellow Springs, Ohio.

GENUS ENCRINURUS.

ENCRINURUS ORNATUS (n. sp.).

Plate 7, fig. 16.

Cybele punctatus, Hall; Pal. N. Y., Vol. II., p. 297, pl. 66a, fig. 1.

Not *Calymene punctatus*, Dal., Hisinger, and others.

Among the fossils from the formation at Yellow Springs, Ohio, there are several specimens of pygidia of a species of *Encrinurus*, one of

which retains parts of five of the thoracic segments attached. The specimens appear to be identical in form, in the ornamentation of the surface, and in the number of segments, with those from the Clinton group of New York, which have been referred to *E. punctatus*, but differ very considerably from the figures and descriptions of that species as given by European authors. Some of the Ohio specimens are considerably larger, and show the markings more distinctly than those illustrated in Vol. II., Pal. N. Y., as above cited.

The form of the pygidium is triangular, as wide, or a little wider, than long, measured on the internal cast, which is the condition in which it occurs. The prolongation of the posterior extremity being much contracted in this condition, the length of the plate on the perfect crust has probably somewhat exceeded the greatest width. The axial lobe forms less than one-third of the entire width, is strongly marked and somewhat flattened on the top, except at the anterior portion, and divided transversely into about twenty or more segments. The center of the lobe is marked by a row of five, prominent, rounded nodes, the anterior one of which is situated on the second segment, the next on the fifth, the others having three segments between each node. It is possible that on the exterior surface of the crust there may have been an additional or sixth node on the terminal segment of the axis, but no evidence of it exists on the specimens examined. The lateral lobes are marked by seven segments, all of which are directed abruptly backwards from their origin at the longitudinal suture, and each segment appears to have been marked near its inner end by a transverse node, and, also, by one or more other nodes further out on the rib.

The thoracic fragments are too imperfect to afford characters for a complete description. The axial lobe is shown to be highly convex, and the lateral lobes flattened for nearly half their breadth, at which point they are abruptly bent downwards and slightly inclined backwards.

Compared with specimens from the Clinton group of New York, there are very few points of difference of any importance, except the more distant nodes on the lateral lobes of the pygidium where the specimens preserve the original crust; but compared with the figures of European authors, the differences are more marked—those all representing a single row of nodes along the middle of each lateral lobe, while the Ohio specimens have had two or more—probably four—on several of the anterior segments. The New York examples show even more than four on the anterior segments. The figures given in Murch. Siluria, plate 10, figs. 4 and 5, differ in the disposition of the nodes on the axial lobe to such

an extent as to preclude the possibility of a specific identification, while there are none represented on the segments of the lateral lobes.

Formation and locality: In limestones of the Niagara group, at Eaton and Yellow Springs, Ohio. Collected by Prof. Edward Orton.

GENUS LICHAS, Dalman.

LICHAS BREVICEPS.

Plate 7, fig. 17.

Lichas breviceps, Hall; Trans. Alb. Inst., Vol. IV., p. 222, 1862.

Among the remains of trilobites from the Niagara group there is a single imperfect glabella and a portion of a pygidium which appears to belong to the above named species. The glabella has been very short and broad, and very distinctly divided into three lobes, the central one being broad and rounded in front, and abruptly contracted posteriorly, but again slightly expanding just in front of the occipital furrow. The lateral lobes are proportionally large, sub-reniform, as long again as wide, and a little wider than the narrowest part of the central lobe, placed with their rounded or convex sides against the central lobe. The front of the head is broadly rounded, and bordered by a very narrow, thickened, cord-like, closely appressed rim. Occipital ring broad and flattened. Surface very finely pustulose, appearing to the unassisted eye only as finely granulose. Eyes and movable cheeks not observed.

The pygidium associated with the glabella is semi-oval, longer than wide—the axis at its anterior end forming a little more than one-third of the entire width, the form being elongate triangular, marked by only two distinct rings, the furrows between them not extending entirely across the lobe, and the posterior extremity of the lobe bluntly rounded. Lateral lobes flattened, marked by three pairs of furrows; but the specimen is too imperfect to show whether there has been more than one point on each side above the central or terminal one; but the evidence, as furnished by the direction of the furrows and striæ on the under surface, would indicate the existence of two points.

The original specimen of *L. breviceps* is from the Niagara group, at Waldron, Indiana, and although, on comparison, there are some slight differences noticed between them, they are not of sufficient importance to be considered of specific value. The species differs from *L. Boltoni*, of the same formation in New York, in the shortness of the head, the greater posterior breadth of the central lobe of the glabella, in the rounded front

of the head, and in the absence of the broad, somewhat projecting and flattened anterior border of that species, and the surface features of the crust are also of much finer texture. From *L. nereus*, Hall (16th Rept-State Cab., p. 226), to which it is closely related, it differs in the proportionally shorter cephalic shield, in the more curved lateral lobes, and in the absence of the anterior prolongation of the border.

Formation and locality: In limestones of the Niagara group, at Yellow Springs, Ohio.

CRINOIDS OF THE GENESSEE SLATE AND CHEMUNG GROUP.

The two following species of Crinoids are of considerable interest from their supposed geological position, coming from formations which have heretofore yielded so few forms of this class. The *Platycrinus* is from rocks which are probably equivalent to the Chemung or Portage of New York, while the other is from beds supposed to be of a corresponding age with the Genessee Slates of New York, a formation that has never yielded any remains of Crinoids within the limits of that State.

GENUS MELOCRINUS, Goldf.

SUB GENUS CTENOCRINUS, Brown.

MELOCRINUS (CTENOCRINUS) BAINBRIDGENSIS (n. sp.).

Plate 13, figs. 2 and 3.

Body rather above a medium size, very broadly turbinate, spreading somewhat rapidly from the base to the origin of the free arms, strongly pentangular in a basal view; dome low pentapyramidal, the highest point nearer to the largest interrarial (anal) area, the summit perforated, and has apparently been surmounted by a very small or slender proboscis; spaces above the interrarial areas somewhat depressed, the whole composed of small polygonal plates, apparently without definite arrangement, except in the depressed areas, where they are indistinctly arranged in transverse lines. The four basal plates form a low vertical rim at the base of the cup, which is slightly lobed by the depression of the suture lines. First radial plates large, a little wider than high, four of them heptagonal, the other hexagonal; second radials hexagonal, wider than high, the widest part mostly above the center of the plate; third radials smaller than the second, but variable in size and form. In the specimen used for description they are heptagonal in the anterior ray, and hexagonal in the left postero-lateral ray, while in the other three they are pentagonal. The supraradials are arranged above the

third radials in double series, one above the other, on each sloping face, the upper ones being short, broad plates, and support a third set, which appear to have been more properly the first arm plates, although they are all more or less broken in the specimen, so that it is impossible to determine fully their true nature. The inner margins of these, and also of the second range of supraradials, are closely pressed together, so as to unite the cicatrices of the two upper plates, on which the arms rest, together forming only a single scar. Interradial areas large, four of them similar in size, but varying in the arrangement of the plates. The first plate in each of these areas is somewhat regularly hexagonal, the height and width being about equal, supporting two smaller plates in the second range, some of which are hexagonal, and others heptagonal; the third range consists of three plates, above which they are not regular, some having three, others four, and in one area there are five plates in this range; above this point they are more properly dome than interr-adial plates. The fifth area, which corresponds to the anal area of the unsymmetrical crinoids, is larger than the other four. The first plate is large, equal in size to the largest of the first radials, and heptagonal in form, supporting three plates in the second range in the form of an arch, with four in each of the two next ranges, each range having the same arcuate feature, which feature continues, though with less distinctness, to near the base of the proboscis.

The surface of all the plates of the calyx are very depressed convex, with slightly concave centers, and more abruptly rounding near the margins; or they may be described as flattened, with the margins roundly beveled, the suture lines presenting the appearance of being widely grooved. The plates of the dome are moderately convex, with very distinct sutures. The plates of the calyx are marked over their entire surface, except the most depressed part of the suture grooves, by a system of small confluent granules arranged in concentric circles. Those of the dome are simply finely granulose.

Associated with the body described are several pieces of columns, of rather less than a fourth of an inch in diameter, composed in some cases of alternating larger and smaller discs, in others of similar sized plates, all having their exterior surfaces longitudinally marked similar to the plates of the body; also, a fragment of an arm, which is very thick and strong in its habit of growth, and is supposed to be an arm of this species, as there is no other form of arm, or of body, found associated with them. The arm is broad and flattened, almost depressed along the center of the back, and is composed of a double series of very short plates, interlocking with each other along the center, but scarcely alter-

nating; every fourth plate on each side is thickened on the outer end, and supports an armlet, which is composed of a single range of short, flat plates, supporting tentaculæ, the precise nature of which can not be satisfactorily made out in the fragment under examination. The armlet-bearing plate of the right side of the arm rests immediately upon that bearing an armlet on the opposite side of the arm, leaving three simple plates between this and the next armlet below.

The species bears considerable resemblance to *Melocrinus breviradiatus* (name issued with explanation of photograph plate, August, 1872), from the Hamilton group of New York, but differs in the less projecting rim at the base of the cup, formed by the basal plates, in the greater inequality of the interradiial and anal areas, and also in the surface character and ornamentation of the plates, as well as in the flattening of the surface of the plates themselves, those of that species being highly convex, approaching tumidity.

The form of the arm bases, together with the character of the arm found associated with it, would indicate the existence of only a single strong arm to each ray, bearing numerous armlets along its sides. This feature is the one peculiarity of the genus *Ctenocrinus*, Brown, as exemplified in *C. stellaris*, Rømer (Pictet's *Traite de Palæont.*, Pl. CI., fig. 1), and to which this fossil, in its structure, bears a striking resemblance, differing only in the possession of four basal plates, which are strongly marked and positively divided in this species, although somewhat more obscure in *M. (C.) breviradiatus*, which appears to be congeneric, while in the generic description given in Brown's *Lethea*, the number of basal plates is said to be only three; but still there seems to be some doubt about it, as the number is followed by an interrogation point. The principal feature, however, claimed for the generic distinction being the form and number of the arms, and the arrangements of the armlets, we prefer to place this species under the genus, believing that the *C. stellaris*, when thoroughly examined, will prove to possess four basal plates. This form of structure will make it in all respects, as far as the body is concerned, the same as in *Melocrinus*, Goldf. The *Melocrinites nodosus*, Hall (Rept. Progr. Geol. Surv. Wisconsin, 1861, p. 19), will probably also prove to belong to this same division of the group.

Formation and locality: In a limestone layer, six inches in thickness, about thirty feet above the base of the Huron Shales (Black Slates), Bainbridge, Ross county, Ohio. Ohio State collection. Collected by Mr. J. H. Poe, of Chillicothe, Ohio.

GENUS PLATYCRINUS, Miller.

PLATYCRINUS BEDFORDENSIS (n. sp.).

Plate 13, fig. 4.

Body of medium size, pocilliform, a little wider than high. Basal plates proportionally large, regularly rounding from the edges of the column to their superior margins, and forming about one-third of the height of the cup. First radial plates large, moderately excavated for the reception of the second radials. Arms, four from each ray, so far as determined; simple above their origin, of moderate strength, and composed of a single series of wedge-formed plates, each of which extends entirely across the arm, and bears tentacula on its longer side, thus giving a tentacle to every alternate plate on each side of the arm. Tentacula rather strong, flexuose, and composed of rather long plates, which are very distinctly grooved along their inner face.

Surface of the plates of the body apparently smooth. Column strong, somewhat pentangular in the upper part, and one example very decidedly spinose on the edge of the plates.

The specimens of this species examined are imbedded in a ferruginous shale, and the characters much obscured thereby, so that the entire structure can not be fully determined, especially near the bifurcations of the arms. It closely resembles *P. Lodensis*, of the Waverly group, in the general form and structure of the arms, but is of a more robust habit, and differs in that the arm plates extend entirely across the arm, instead of only partially across, as in that species.

Formation and locality: In the upper part of the Erie shale, Bedford, Ohio. Collection of Columbia College, New York.

CRINOIDEA OF THE WAVERLY GROUP.

GENUS ACTINOCRINUS, Miller.

ACTINOCRINUS DAPHNE.

Plate 11, fig. 11.

Actinocrinus Daphne; 17th Rept. on the N. Y. State Cab. of Nat. Hist., p. 52, 1864. Extr. published in advance, Albany, Nov. 11, 1863.

Body broadly turbinate, of medium size; base slightly projecting over and beyond the column, with a groove just within the basal margin. Basal plates of moderate height, and barely indented at the suture lines. First radial plates larger than any others in the body; second radials hexagonal; third radials pentagonal, hexagonal, and heptagonal (sometimes the upper lateral angles being simply truncated), smaller than the second radials, supporting on the upper oblique edges a simple supraradial plate on each side. These latter, from the outer sloping side, give origin to a simple arm, and on the inner superior side they support a bifurcated plate which gives origin to two arms, making six arms to the ray. One of the rays (probably the anterior one) exhibits some appearance of having but five arms. This would give a formula of

$$\frac{5}{\frac{6}{6} \frac{6}{6}} = 29 \text{ arms.}$$

In the interradian series the lower plate is hexagonal, supporting two in the second range, above which they are not known.

Arms long and slender, not bifurcating, composed of a double series of short plates. The arms in the middle of their length often become flattened on the back, and in their upper part grooved along the junction of the plates, the surfaces of which are longitudinally striated in the lower part, becoming nodose above.

Tentacula long and slender, composed of several joints, each of which supports an ascending spine.

Surface of plates marked by radiating ridges extending from the center to the margins. Approaching the divisions of the ray, and in the supraradial series, the plates become angulated along the center in the direction of the ray.

Column large, round, composed of alternating larger and smaller joints.

This species resembles the *A. eucharis* and *A. Calypso*, of the Hamilton group, differing from the first in the number of arms, and in having the subdivisions of the ray beginning as it becomes free from the cup; and from the latter it differs in the greater number of arms from the ray, as well as in the angular character of the supraradial plates.

Formation and locality: In shales of the Waverly sandstone group, at Richfield, Summit county, Ohio.

ACTINOCRINUS HELICE.

Plate 11, figs. 5-8.

Actinocrinus helice; 17th Rept. on the N. Y. State Cab. of Nat. Hist., p. 53, 1864. Extr. published 1863.

Body short, broadly turbinate, the base overhanging the column. Basal plates somewhat deeply notched at the suture lines; first radial plates proportionally large; second radials small, quadrangular; third radials slightly larger than the second, pentangular, supporting supraradial and brachial plates on the upper sloping sides.

In the anterior ray the third radial supports simple brachial plates only, giving origin to two arms; in the antero-lateral rays the third radial supports a supraradial or bifurcating plate on one side, and simple brachial plates on the other, giving three arms. Sometimes there are two bifurcating plates in these rays, giving origin to four arms in one or both these rays.

In the postero-lateral rays the third radial plate supports a bifurcating supraradial on each side, giving origin to four arms to each ray, making a formula of

$$\frac{2}{3}\frac{3}{4}=16 \text{ arms, or } \frac{2}{3}\frac{4}{4}=17 \text{ arms.}$$

A constant feature of this species, so far as observed, is the existence of two arms in the anterior ray, and four in each of the postero-lateral rays, while in the antero-lateral divisions there may be two, three, or four arms in one or both rays.

Interradial areas with the first plate large, and one or two plates above it. First anal plate large, heptagonal, round and nodiform in the middle, supporting three plates in the second range, with two or three small ones above.

Arms stout and of moderate length, composed of a double series of plates, the center of which are elevated, producing transverse angular ridges. In the upper part of the arms these ridges are broken into nodes, which are sometimes sharply elevated.

Surface of plates usually strongly nodose, becoming sub-angular or ridged towards the margins.

Column comparatively strong, composed of very thick, unequal joints, the larger ones being angular on the periphery, and sometimes showing a tendency to produce small nodes.

This species is of the type of *A. unicornis*, of the Burlington limestone, and is nearly related to *A. præcursor*, of the Hamilton group; but that one has a stronger body and more robust arms, with but three arms from each ray. It may also be compared with *A. cauliculus*, of the Hamilton group, which has a smaller and less spreading base, with more numerous and less spreading arms.

Formation and locality: In shales of the Waverly group, at Richfield, Summit county, Ohio.

ACTINOCRINUS ERIS.

Plate 11, figs. 9, 10,

Actinocrinus helice, var. *Eris*; 17th Rept. on the N. Y. State Cab. of Nat. Hist., p. 53.

Body short and broadly turbinate, somewhat lobed at the divisions of the rays. Basal plates small, slightly projecting at their lower margins; first radial plates proportionally large, wider than high; second radials small, quadrangular; third radials larger than the second, wider than high, very obtusely wedge-form above, supporting brachial plates in the anterior and antero-lateral rays, giving two arms to each; in the postero-lateral rays the third radials support supraradials on the anal side and brachials on the other side, giving three arms to each of these rays.

This structure gives a formula of

$$\frac{2}{3} \frac{2}{3} = 12 \text{ arms.}$$

Interradial areas small, the first plate large, heptagonal or octagonal, with one or two plates above. Anal area large, the first plate large, heptagonal, supporting three smaller plates in the second range.

Arms proportionally large and strong, composed of a double series of short, interlocking plates, which are ridged transversely. Plates of the body depressed convex, sub-angular in the upper series.

This species corresponds with *A. helice* in general form and proportions, but the plates of the body are not nodose, and the arm formula differs conspicuously, there being in this but three arms to each of the postero-lateral rays, while that has four. From this constancy of char-

acter, with other differences of less importance, it seems proper to recognize this form as a distinct species, under the name used to designate the varietal form.

Formation and locality: In shales of the Waverly sandstone group, at Richfield, Summit county, Ohio.

ACTINOCRINUS VIMINALIS.

Plate 11, figs. 12-14.

Actinocrinus viminalis; 17th Rept. on the N. Y. State Cab. of Nat. Hist., p. 54. Extr. published 1863.

Body short and spreading, broadly cyathiform, and deeply lobed at the rays. Basal plates very small; first radial plates proportionally large; second radial plates broad, quadrangular; third radials very short and broad, pentangular, supporting brachial plates on their upper sloping sides.

Arms two from each ray, simple at their origin, and composed of a double series of plates beyond the third or fourth above the third radial. The arms are usually almost regularly bifurcating near the base, and unequally divided above. Above the first bifurcation, one of the divisions often continues simple, while the other becomes subdivided, and not unfrequently both are subdivided. In the anterior ray of one individual the arm is bifurcated at the regular distance below, one division again subdividing into three and the other into five arms or branches. The mode of bifurcating differs from the ordinary forms of *Actinocrinus*, where the arm is composed of a double series of interlocking plates; the usual mode being, that the axial plate extends entirely across the arm at the base of the division, while in this one the axial plate is small and pentagonal, intercalated between those of the outer ranges on each side, which are continued without interruption.

The interradian areas consist of one small plate below with two elongate plates above, which are situated between the bases of the arms. The first anal plate is smaller than the first radial; and above this they have not been determined.

Dome large, ventricose, somewhat lobed in the direction of the rays, composed of numerous small, flat, polygonal plates.

Plates of the body little convex, somewhat elevated along the middle or approaching to sub-angular, with surface striato-granulose; plates of the arms nearly smooth, with a sub-angular elevation near the upper margin.

Column of medium proportions, composed of alternating thicker and thinner joints.

In the mode of arm-bifurcation this species resembles the *A. Whitei*, of the Burlington limestone; the form of the body is very different. In this, the arms become free above the third radial plates, while in that they are united to the cup by interbrachial plates, and rise from the body in ten divisions; and these are free before subdividing, and present but five arms where they become free from the body.

Formation and locality: In shales of the Waverly sandstone group, at Richfield, Summit county, Ohio.

GENUS PLATYCRINUS, Miller.

PLATYCRINUS CONTRITUS.

Plate 11, fig. 4.

Platycrinus contritus; 17th Rept. on the N. Y. State Cab. of Nat. Hist., p. 54. Extr. published 1863.

Body broad and short, broadly truncate and concave at the base for the reception of a large column. Basal plates forming not more than one-third the height of the cup, projecting at the base; first radial plates wider than high; second radials sub pentangular, with short lateral sides.

Arms short and strong, composed of a double series of plates, bifurcating on the second radial. Divisions, four from each ray, except on the postero-lateral ones, where there are three on the anal side, making five to each of these rays, giving a formula of

$$\frac{4}{\frac{1}{5} \frac{1}{5}} = 22 \text{ arms.}$$

Surface smooth. Column unknown.

This species is of the type *P. Burlingtonensis*, and its varieties.

Formation and locality: In shales of the Waverly sandstone group, at Richfield, Summit county, Ohio.

PLATYCRINUS GRAPHICUS.

Plate 11, fig. 2.

Platycrinus graphicus; 17th Rept. on N. Y. State Cab. of Nat. Hist., p. 55. Extr. published 1863.

Body sub-hemispherical, rounded below, the basal plates making less than one-third the height of the calyx. First radial plates wider than high; second radials broad and short, sub-pentagonal.

Arms comparatively long and slender, composed of a double series of plates, rising from the second radial in pairs; again subdividing on the second supraradial in one division, and in the other divisions, on the third or fourth plate above, giving, as far as can be determined, four arms from each ray.

Surface of plates obscurely marked by radiating lines of nodes.

Column composed of alternating thicker and thinner joints.

This species differs from *P. contritus* in having longer and more slender arms, and but four from each ray. The calyx also differs from that one in being nodose, at least on the radial plates; also, the basal plates are smaller, and destitute of the projecting rim at their lower margins.

In the separated basal portions, and in the first radial plates, this species bears some resemblance to *P. eboraceus*, of the Hamilton group of New York.

Formation and locality: In shales of the Waverly sandstone group, at Richfield, Summit county, Ohio.

PLATYCRINUS RICHFIELDENSIS (n. sp.).

Plate 11, fig. 1.

Body broadly rounded, cup-shaped, approaching to hemispherical; very slightly truncate at the base for the reception of the column, and marked by a faint ring around the very small cicatrix. Basal plates forming about one-half the height of the calyx, and proportionally very large. First radial plates apparently wider than long, the exact proportions not fully determined, their upper margins slightly excavated for the support of the second radials, the scar extending not more than half the width of the plate and very shallow. Second radials small, obtusely wedge-form above; the lateral margins very short, and, in some of the rays, apparently forming an edge. Interradial plates not observed, but the species would indicate them as being of moderate size.

Arms long, very slender, rising in pairs from the second radial, and bifurcating on the second supraradial, so far as determined; above this bifurcation they are simple throughout, and gradually decrease in size, the extremities being only thread-like; composed of a double series of obtusely wedge-form plates in the lower part, the sharp or narrow edges of which extend nearly across the arm; in the upper part the arm plates are proportionally longer, and extend entirely across, but separating very slightly the two adjacent plates on the opposite side, making a

single range of plates, with their longer faces alternately on opposite sides. Thus in the upper part of the arm each alternate plate bears a tentacle, and in the lower part of the arm each plate on each side gives origin to tentacula. The tentacula are of moderate strength, rather short, but composed of proportionally very long plates, which are carinate on the back. The tentacula-bearing side of the arm plates is characterized by a strong, projecting, spur-like process, upon which the tentacula rest.

The plates of the calyx are smooth to the naked eye, or under a lens of moderate power. The arm plates have the margin bordering the suture lines slightly elevated in the lower and middle portions of their length.

Column small, round, composed of alternating larger and smaller plates, the outer edges of which are rounded.

This species strongly resembles *P. graphicus* in many features; but the arms are less strong, and arm plates different, the *P. graphicus* having two distinct ranges of equal plates interlocking on the back and each plate bearing tentacula, dividing on the second supraradial in one division and on the third in the other divisions of the ray; while these divide on the second supraradial in each division, so far as can be determined from the specimen.

There may be some little doubt of the true generic relations of this fossil, which can only be verified by the examination of more perfect specimens. The whole aspect and mode of growth is that of *Dichocrinus*; but all the plates that are seen of the first radial range appear to be arm-bearing plates; the divisions of the basal series can not be distinctly traced.

Formation and locality: In the shales of the Waverly group, at Richfield, Summit county, Ohio.

PLATYCRINUS LODENSIS (n. sp.).

Plate 11, fig. 3.

Body of moderate size, broadly pocilliform, the basal plates spreading horizontally to near their outer extremities, above which the radial plates appear but little expanded, with arm bases very strong in proportion to the size of the body. Basal plates low and broad, forming a low, pentangular, cup-shaped disc. First radials rather large; height and width, measured to the top of the lateral faces, about equal, the upper surface protruding in the center, and deeply excavated for the support of the somewhat broad, short, second radial plates, which are very broadly

or obtusely cuneate above, and support each two supraradials on each side, one above the other; the upper of these is a bifurcating plate, and supports the first arm plates, one on each slope, giving four arms to each ray, arranged in even pairs.

Arms of moderate length, proportionally strong, of nearly equal size throughout the entire length, full and rounded on the sides and back, composed of a double series of short, broad plates, interlocking at their inner edges along the middle of the outer side of the arm. Tentacula not discovered, but doubtless existed on each plate.

Surface of the plates of the body apparently smooth or very finely granulose; surface of arm plates finely granulose, the suture lines very faintly channeled.

This species differs from *P. graphicus* in the form of the calyx, which is much broader below, and also in the strong, protruding arm bases. It belongs to the group of the genus represented by *P. Wortheni* and *P. Shumardiana*, but is specifically distinct from any we have seen, and differs from the two named in the absence of ornament on the calyx, in its greater height, and in the arm arrangement.

Formation and locality: In the calcareous layers of the Cuyahoga shale, Waverly group, at Lodi, Medina county, Ohio. Collection of Columbia College, New York.

GENUS FORBESIOCRINUS, DeKoninck.

FORBESIOCRINUS COMMUNIS.

Plate 12, figs. 3-5.

Forbesiocrinus communis; 17th Rept. on N. Y. State Cab. of Nat. Hist., p. 55, 1864. Extr. published 1863.

Body in the young state regularly turbinate, and becoming more spreading in older specimens. Basal plates sometimes appearing as a thicker projecting rim, more or less complete, at the summit of the column; sub-radial plates small, sub-triangular, the lateral edges scarcely truncate. Primary radials, four, wider than high; secondary radials, from four to seven, varying in the different rays, smaller than the primary radials, and in different proportionate strength in different individuals. Each ray is usually three times divided, and rarely some one of the divisions again bifurcates, while in some individuals the third bifurcation is not complete.

The interrarial spaces in the older individuals are marked by the presence of a single plate, while in the young specimens no distinct plate,

but only a granule, is visible. The first anal plate is small, with two or three granules above it. The patelloid plates of the rays, and their divisions, are distinctly visible throughout all parts of the body.

The column, near its summit, is composed of the thin joints characteristic of species of this genus, with longer and irregular joints below, sometimes prominent in the middle, giving them an annulated character.

In this species we have the characters of the lower part of the body seen in some of the Carboniferous species of the age of the Keokuk limestone, at Crawfordsville, Indiana, where there are no interradiial plates, and the anal area has but one distinct plate. In those species the rays are continued above the first bifurcation, throwing off lateral armlets, but not properly bifurcating. All the Carboniferous species, with regularly bifurcating arms, as in this one, have interradiial areas, with numerous plates. This species, therefore, combines in part the characters belonging to two Carboniferous types of the genus, but possesses neither of them fully.

A specimen from the Chemung group, at Forestville, Chautauqua county, New York, exhibits all the characters shown by this species, so far as can be seen in a single individual, one side of which is imbedded in the rock.

Formation and locality: In shales of the Waverly sandstone group, at Richfield, Summit county, Ohio.

FORBESIOCRINUS TARDUS.

Plate 12, fig. 2.

Forbesiocrinus lobatus, var. *tardus*; 17th Rept. on N. Y. State Cab. of Nat. Hist., p. 56, 1864. Extr. published November, 1863.

Body somewhat moderately expanding above the base, and deeply lobed. Basal and sub-radial plates undetermined, very small. Primary radials, three in each ray, so far as seen, the third one prominent, tumid or sub-nodose in the center. Secondary, or first supraradials, from three to five in each division; above this the number of plates is very irregular.

Arms bifurcating two or three times above the the third supraradial, and rapidly diminishing in size.

On the anal side a single narrow elongate plate is visible, the remainder of the anal area undetermined.

The plates of the body are very convex along the middle exteriorly,

and in the arms becoming angular on the back, the bifurcating plates being very tumid or nodose, and those of the upper part of the arms more prominent or sub-spinous. Upper margins of the plates of the body and rays deeply concave exteriorly.

Surface apparently finely granulose.

Column, near the body, of moderate size, round, and rapidly tapering below, composed of thin plates.

A moderately well-preserved specimen of this crinoid shows no essential or important difference from *F. lobatus*, of the Hamilton group of New York, described in the Fifteenth Report on the State Cabinet, page 124. The divisions and subdivisions of the rays are precisely of the same character, and in the same order. The rays are sub-angular, and the third radial plate is more prominent than other parts of the ray, though from its weathered condition it is not so prominent.

In the specimen under consideration the plates of the ray are not quite so deeply depressed in the middle as the original of *F. lobatus*, but this difference may be in part due to the greater pressure which this one has undergone. In the typical *F. lobatus* the interradiial series consists of several plates, while in this one the character of these areas can not be determined. An examination of better specimens may prove the absence of these plates in the form under consideration, which would entitle it to a distinct specific rank; but in the presence of similar interradiial areas we can see no reason for a specific separation of the specimens from the two localities.

The difference in geological position is greater than we know in any other species of this family of fossils, the *F. lobatus* being from the upper part of the Hamilton group. At the same time we know several species of Lamellibranchiate fossils which extend from the Hamilton to the Waverly group.

Formation and locality: In shales of the Waverly group, Richfield, Summit county, Ohio.

FORBESIOCRINUS KELLOGGI.

Plate 12, fig. 1.

Forbesiocrinus Kelloggi; 17th Rept. on N. Y. State Cab. of Nat. Hist., p. 56, 1864. Extr. published November, 1863.

Body and arms somewhat robust; body short. Basal plates barely visible above the column; sub-radial plates small and triangular. The primary radial series consists of four plates in each ray, which diminish

from below upwards. The secondary radial series consists of five in each division between the first and second bifurcations, while there are from six to eight plates in each division between the second and third bifurcations. The antero-lateral interrarial areas have one somewhat prominent plate of medium size, which rests upon two adjacent first radials, and lies between the second radial plates. The postero-lateral interrarial spaces have a single smaller plate situated as in other spaces. The first anal plate is about as large as the larger interrarial plate. No other plates have been determined above.

The branches of the ray divide twice above the first bifurcation, and each bifurcating plate is strongly nodiferous, the node angular and transverse. The surface of the ray, as far as the first division, is regularly convex, and the divisions become successively more angular upon the back. The surface of the plates is strongly striato-granulose.

Column strong, composed near the body of very thin plates, and rapidly tapering below.

In the structure of the body this species is most nearly allied to *P. communis*, differing in the nodose bifurcating plates and in the angular divisions of the ray.

Formation and locality: In shales of the Waverly sandstone group, at Richfield, Summit county, Ohio.

GENUS POTERIOCRINUS, Miller.

POTERIOCRINUS CRINEUS.

Plate 12, figs. 6, 7.

Poteriocrinus crineus; 17th Rept. on N. Y. State Cab. of Nat. Hist., p. 56, 1864. Extr. published in 1863.

Body turbinate, of medium size. Sub-radial plates of moderate size. First radials wider than high; second radials shorter than the first, strongly wedge-form above, supporting an arm on each upper sloping side, making two arms to each ray.

The anal area has apparently three plates attached to the calyx, while the upper part of the area is not visible in the specimens examined.

Arms dividing on the tenth or twelfth plate from their origin, composed of a single series of plates, which are alternately longer and shorter on their opposite sides, bearing strong tentacula on the upper part of their longer side.

In the specimen figured, a single arm on the right postero-lateral ray is subdivided a second time; but, as the specimen is incomplete at the summit, it can not be determined whether any of the other arms bifurcate.

Surface smooth, or finely granulose, without distinct markings.

Formation and locality: In shales of the Waverly sandstone group, at Richfield, Summit county, Ohio.

POTERIOCRINUS PLEIAS.

Plate 12, fig. 8.

Poteriocrinus pleias; 17th Rept. on the N. Y. State Cab. of Nat. Hist., p. 57, 1864. Extr. published in 1863.

A species of small or medium size. Body somewhat broadly turbinate, more expanding in the upper part; basal plates short; sub-radial and radial plates comparatively short. Second radials about as wide as long, larger than the first radials, supporting on each upper sloping side an arm. Anal plates small and numerous, extending upwards into the proboscis.

Arms composed of a single series of long, sub-cuneiform plates, which bear tentacula on their longer side. The arm is simple to the eighth plate; above this unknown.

Surface smooth, or finely granulose. Column sub-pentagonal, composed of alternating thicker and thinner plates.

This resembles *P. crineus*, but is more slender in form and structure, and the arm joints are proportionally larger.

Formation and locality: In shales of the Waverly group, at Richfield, Summit county, Ohio.

POTERIOCRINUS (SCAPHIOCRINUS ?) CORYCIA.

Plate 12, fig. 9.

Poteriocrinus corycia; 17th Rept. on N. Y. State Cab. of Nat. Hist., p. 57, 1864. Extr. published 1863.

A species with a small, short, and somewhat broadly turbinate body. The basal plates are wider than high, pentangular. Sub-radial plates proportionally large; first radial plates once and a half as wide as high; second radial plates as high as wide, or higher than wide, on the antero-

lateral and postero-lateral rays; supporting on their upper sloping sides arms which bifurcate on the tenth plate above, with probably a second bifurcation above this one. The second radial of the anterior ray is twice as long as wide, truncate above, and supporting a single arm, which bifurcates on the fourth plate above, giving six plates in the ray below the bifurcation. Anal plates unknown.

Surface somewhat strongly granulose.

This species bears considerable general resemblance to *P. cauliculus*, of the Burlington limestone, but differs essentially in the structure of the arms.

Formation and locality: In shales of the Waverly group, Richfield, Summit county, Ohio.

SUB GENUS SCAPHIOCRINUS.

SCAPHIOCRINUS (POTERIOCRINUS) ÆGINA.

Plate 12, figs. 11, 12.

Scaphiocrinus (Poteriocrinus) ægina; 17th Rept. on the N. Y. State Cab. of Nat. Hist., p. 57, 1864. Extr. published 1863.

Body short, turbinate, or sub-hemispheric. Basal plates very short, triangular. Sub-radials about as wide as long, a little smaller than the first radial plates. Radial series consisting of three plates; the first one large, wider than high, and a little projecting at the upper margin; second one short and wide, quadrangular, somewhat constricted in the middle. The third radials are obtusely wedge-form above and strongly constricted in the middle, and supporting a single arm on each upper sloping side. Plates of anal area large in the lower part, and gradually decreasing above.

Arms simple throughout, composed of elongate, sub-cylindrical joints, which give origin to strong jointed tentacula from near the upper margin of their longer sides. These arm plates are enlarged at the origin of the tentacula, which are alternate on the opposite sides of the arm, giving it a tortuous direction.

Column proportionally strong, sub-pentagonal, composed of alternating long and short joints, with still longer ones at irregular intervals; the longer joints are wider and sub-nodose on the periphery.

Surface of plates granulose; those of the body slightly convex.

In general appearance this species resembles *Poteriocrinus diffusus*, of the Hamilton group, to which it is also closely related, but differs in

having a shorter and comparatively broader body and much shorter basal plates. In this species every arm joint bears tentacula, while in the Hamilton species the tentacula are only on every second or third joint.

Above the horizon of the *Poteriocrinus diffusus* there are as much as one thousand feet of Genessee slate and Portage rocks, and one thousand feet of beds belonging to the Chemung group of New York, before reaching the horizon to which these fossiliferous beds in Ohio have been referred.

Formation and locality: In shales of the Waverly group, at Richfield, Summit, county, Ohio.

SCAPHIOCRINUS (POTERIOCRINUS) LYRIOPE.

Plate 12, fig. 10.

Scaphiocrinus (Poteriocrinus) lyriope; 17th Rept. on the N. Y. State Cab. of Nat. His., p. 58, 1864. Extr. published 1863.

Body small, sub-turbinate. Basal plates of moderate height, and much wider than long. Sub-radial plates about equal in height and breadth; first radial plates about once and a half as wide as high; second radials much higher than wide, some of these twice as high as wide, strongly constricted on the sides, obtusely wedge-form above, and supporting an arm on each upper sloping face.

Arms long and slender, composed of a single series of elongate, curving plates, which are alternately longer and shorter on the opposite sides, and constricted in the middle. A single arm is seen to bifurcate on the tenth plate above its origin. The upper lateral angle of each arm plate is much thickened and expanded for the attachment of strong tentacular plates. The tentacula are composed of strong, elongate plates, which are distinctly grooved on the inner face; the exterior surface longitudinally striated.

Surface of plates of the body and arms distinctly striato-granulose.

Column near the body small, round, or very obtusely pentagonal, and composed of irregularly alternating longer and shorter plates.

In general features this species resembles *Poteriocrinus ægina*, but is somewhat more delicate, and the calyx scarcely so spreading. The second radial is a bifurcating plate (instead of the third), and is much longer than the third plate in *P. ægina*; the arms and tentacula are more slender; the arm plates not so prominent at the the junction of

the tentacles, and therefore not so tortuous; the surface of body and arms is more distinctly striato-granulose, and the column more round, with plates not so unequal.

Formation and locality: In shales of the Waverly group, Richfield, Summit county, Ohio.

SCAPHIOCRINUS SUBCARINATUS.

Plate 12, figs. 13, 14.

Scaphiocrinus subcarinatus; 17th Rept. on N. Y. State Cab. of Nat. Hist., p. 58, 1864. Extr. published 1863.

Body small, sub-turbinate, with elongate, slender, branching arms. Basal plates very minute, triangular or sub-pentagonal; sub-radials small; first radials wider than high; second radials larger than the first, unequal in height, longer than wide, and strongly constricted in the middle, obtusely wedge-form above, and supporting an arm on each sloping face.

Arms bifurcating on the sixth, eighth, or tenth plate, and sometimes on the fourteenth plate from their base, each of the divisions again bifurcating; arm plates supporting jointed angular tentacula. Anal plates unknown.

Plates of the body angular in the middle, with short, angular ridges running from the center of the sub-radials to the basal plates, and also to the first radial plates. The second radials, as well as the arm plates, are longitudinally angulated or carinate along the middle. The carination follows the enlargement of the arm joint towards the origin of the tentacula, giving a somewhat tortuous direction to the arm. Entire surface minutely granulose, or sometimes striato-granulose.

Column round or obscurely pentangular, and composed of very unequal joints.

This species closely resembles *Scaphiocrinus carinatus*, of the Burlington limestone, but differs in the bifurcation of the arms, and more essentially in having but two radial plates in the series, while that species has three.

Formation and locality: In shales of the Waverly sandstone group, at Richfield, Summit county, Ohio.

SCAPHIOCRINUS SUBTORTUOSUS.

Plate 12, figs. 15, 16.

Scaphiocrinus subtortuosus; 17th Rept. on the N. Y. State Cab. of Nat. Hist., p. 59, 1864.
Extr. published 1863.

Body small, cyathiform. Basal plates minute; sub-radial plates about as long as wide. First radial plates nearly twice as wide as long; second and third radial plates very short, but longer on the anterior ray, the third radials obtusely wedge-form above, and supporting two arms, which bifurcate on the ninth and twelfth plates from their origin. No other bifurcations of the arms have been determined. First anal plate large, pentangular; the others unknown.

The plates of the body are very prominent in the middle, with strong angular ridges extending to the margins, and joining those of the adjacent plates. Arm plates constricted in the middle, and longitudinally sub-angular.

In the structure of the calyx, form and character of the plates, this resembles the *S. tortuosus* of the Burlington limestone, but in the arm structure, and the existence of three radial plates in the series, it more nearly resembles the *S. carinatus* of the same formation.

Formation and locality: In shales of the Waverly group, at Richfield, Summit county, Ohio.

GENUS ZEACRINUS, Troost.

ZEACRINUS PATERNUS.

Plate 12, fig. 17.

Zeacrinus paternus; 17th Rept. on the N. Y. State Cab. of Nat. Hist., p. 59, 1864.
Extr. published 1863.

Body small; calyx depressed or broad cyathiform. Basal plates very small, concealed within the cavity of the column attachment. Sub-radials of moderate size, wider than high, their lower margins curving into the basal depression. First radials as wide again as high, concave on their upper margins; second radials, in the antero-lateral and postero-lateral rays, sub-equal, or a little wider than high, obtusely wedge-form above, and supporting an arm on each sloping side; each of these arms, in the antero-lateral ray, bifurcates on the eighth or tenth plate above its origin, and the outer branch again bifurcates, while the inner re-

mains simple. The bifurcations of the postero-lateral rays have not been determined.

In the anterior ray the second radial plate is truncate above, and supports a single arm, which divides on the fifth plate above the second radial, or the seventh in the series, and again bifurcates on the tenth plate in one division, and on the twelfth plate in the other, above which it continues simple. Arms rounded on the back, composed of a single series of very short plates, much swollen at the bifurcations. Anal plates unknown.

Surface of the plates nearly smooth, or with arching lamellose striæ.

Column small, round, composed near the body of thin, alternately larger and smaller, plates.

This species closely resembles the *Z. scoparius*, of the Burlington limestone, in general features and in the bifurcation of the arms, but differs in having a more spreading calyx and a much greater proportional length of arms, with thicker arm plates, and not flattened on the back, as that species. The anterior ray also differs, that one having but two plates between the second radial and the first bifurcation.

Formation and locality: In shales of the Waverly sandstone group, at Richfield, Summit county, Ohio.

ZEACRINUS MEROPE.

Plate 12, fig. 18.

Zeacrinus merope; 17th Rept. on N. Y. State Cab. of Nat. Hist., p. 60, 1864. Extr. published 1868.

Body small, very broadly turbinate, sub-pentangular above from the prominence of the second radial plates. Basal plates small, triangular; sub-radial plates about equal in length and breadth. First radials nearly twice as wide as high; second radials equal in height and width, constricted in the middle and angulated longitudinally, each one of them supporting a pair of arms which rise from the upper sloping sides of the plate. In the antero-lateral rays the arms bifurcate on the sixth and eighth plates from their base, the outer division again bifurcating on the tenth plate above the first division, and the inner division continuing simple throughout. In the anterior ray the second radial plate is truncate above; and the second plate above this, or the fourth plate in the radial series, becomes a bifurcating plate, supporting two arms, which bifurcate on the tenth plate above their origin. Anal plates small.

Arms composed of short, wide, equal sided plates, which are angular on the back. The surface of the arm plates is striato-granulose.

The plates of the body are marked by indistinct radiating ridges, which show a tendency to become nodose. The second radial plates are strongly angular, and sub-carinate along the middle.

Column near the body composed of thin, unequal plates, and shows a tendency to become sub-angular below.

This species differs from *Z. paternus* in the turbinate form of the calyx, the angulated and sculptured surface of the body, and the sub-angular form of the arms. In the anterior ray it differs in having the division of the arms take place on the fourth plate in the radial series, instead of the seventh. In this respect, and in the bifurcation of the antero-lateral and postero-lateral rays, this species corresponds precisely with *Z. scoparius*, but differs in the sub-carinate and carinate character of the plates of the body, which are ornamented by minute nodes, or nodose ridges, while the basal plates are a little more distinctly marked than in that.

Formation and locality: In shales of the Waverly group, at Richfield, Summit county, Ohio.

DESCRIPTION
OF THE
CORALS OF THE SILURIAN AND DEVONIAN SYSTEMS.

BY
H. ALLEYNE NICHOLSON.

To DR. J. S. NEWBERRY, *State Geologist*:

DEAR SIR: I have the honor to respectfully submit to you the following report on the Fossil Corals of the State of Ohio. In addition to the true Corals, I have included in this report descriptions of some of the more abundant and characteristic *Polyzoa*, as well as of a remarkable group of Silurian and Devonian Sponges, both of which come under the head of "Corals," commonly so called.

As the specimens of various of the species of Corals are in a condition of preservation which allows of nothing more than the mere determination of their occurrence in given formations, I have not always thought it necessary to give descriptions of these, especially when they are well known forms; but I have, on the contrary, thought it sufficient to merely note their presence.

Many of the specimens, on the other hand, are unique in their exquisite condition of preservation. Some of the previously recorded forms exhibit characters not heretofore observed, and there is a large number, comparatively speaking, of species altogether new to science. Of these I have in all cases given a full description, accompanied, where practicable, by illustrative figures.

I desire, in this connection, to acknowledge the deep obligation under which I am to Mr. U. P. James, of Cincinnati, for the use of numerous rare and often unique specimens from his large and valuable collection of fossils from the Cincinnati rocks, as well as for the valuable information which he has afforded me on various points, which I should otherwise have found it difficult to elucidate. I am also greatly indebted to Prof. Edward Orton, President of the Ohio Agricultural and Mechanical College, for the liberality with which he placed at my disposal many interesting specimens from his private collection, and for the cordial assistance which I have received from him in my inquiries.

Finally, in justice to myself, I may state that I have had to contend with some exceptional difficulties in the preparation of this report. I have not, namely, been always able to compare certain of the known species with typical examples of the same from other regions, and have, therefore, been compelled to decide as to their characters simply from the evidence actually in my possession. Secondly, I have found it impossible to obtain in this place certain of the memoirs upon this class of organisms, to which I would otherwise have gladly referred. In some instances, therefore, I have been unable to arrive at decisive conclusions on points which could otherwise have been decided without difficulty, and I have not always been in the position to give the necessary references, or to complete the synonymy with absolute fullness.

I have the honor to remain, dear sir,

Yours, very respectfully,

H. ALLEYNE NICHOLSON.

UNIVERSITY COLLEGE, TORONTO, May 11, 1874.

CORALS OF THE CINCINNATI GROUP.

CŒLEENTERATA.

ACTINOZOA.

GENUS FAVOSITES, Lamarek, 1816.

(Hist. des An. Sans Vert., Vol. II., p. 201.)

The genus *Favosites* comprises branched or massive corals, composed of numerous more or less polygonal corallites, the walls of which are not amalgamated with one another, and which have the visceral cavity partitioned off by transverse diaphragms or "tabulæ," which are sometimes more or less rudimentary. The walls of the corallites are perforated by one, two, three, or more rows of "mural pores," by which the separate corallites are placed in communication with one another. The septal system is entirely unrepresented, or is quite rudimentary, consisting at most of short spiniform projections or tubercles.

The genus *Favosites* (including under this name *Emmonosia*, Edw. and H., and *Astrocerium*, Hall) has a vast development in the Upper Silurian and Devonian periods, but is comparatively poorly represented in Lower Silurian deposits. This arises in part from the fact that the genus had at this early period undoubtedly not attained its full development, and in part from the difficulty which is often experienced in separating imperfectly preserved examples of the genera *Columnaria* and *Favistella* from *Favosites* proper. So far as the Cincinnati group of Ohio is concerned, I have only seen two examples which I could refer with certainty to the genus *Favosites*, and in both of these it was not possible to arrive at an absolutely certain specific determination.

FAVOSITES GOTHLANDICA, Lamarek(?).

(For the synonymy of this species, see its description later on.)

The determination of the different species of *Favosites* depends upon the diameter of the corallites, their general form, and their equality or inequality in point of size; the completeness or incompleteness of the tabulæ, and the form of these structures and their number in a given

space; the number of the rows of mural pores, and the position of these openings on the flat surfaces or the angles of the corallites; and in the presence or absence of rudimentary septa. Individual specimens rarely exhibit more than a few of these characters, and it is, therefore, often a matter of impossibility to determine with absolute accuracy to what species of *Favosites* a given example should be referred. Hence I am not prepared to assert positively that the specimen here referred to *F. Gothlandica*, Lam., really is of this nature, though it has all the external characters of this species.

The specimen in question is a small, rounded, depressed-hemispheric mass, composed of sub-equal polygonal corallites, which have an average diameter of about one line. The walls of the corallites are thin, there are no traces of septa, and the characters of the tabulæ and mural pores can not be determined. The specimen is beyond all question a true *Favosites*, and it may with the greatest probability be regarded as the young of *F. Gothlandica*, with which it agrees in form and in its general proportions.

Position and locality: Cincinnati group, Cincinnati, Ohio.

GENUS FAVISTELLA, Hall.

(Pal. N. Y., Vol. I., p. 275, 1847.)

Corallum aggregate, massive, hemispheric, pyriform, or sub-globose, composed of prismatic corallites, with compact imperforate walls, which are usually completely amalgamated with one another. Septa well developed, lamellar, of unequal sizes, the primary ones extending nearly or quite to the center of the visceral chamber. No columella. Tabulæ well developed and complete.

This genus is more nearly allied to *Columnaria* than to *Favosites*; but it appears to be sufficiently distinct from both. From the latter of these genera, *Favistella* is distinguished by the absence of mural pores, the well-developed septal system, and in *Favistella stellata*, at any rate, the amalgamation of the walls of the corallites. On the other hand, whilst agreeing with *Columnaria* in the possession of imperforate walls and by distinct septa, *Favistella* is separated from the former genus, as usually understood, by the fact that the septa extend to, or near to, the center of the theca, instead of being comparatively rudimentary, the walls of the corallites being at the same time usually inseparably united with one another. Lastly, from *Columnopora*, Nich., the present genus is distinguished by the absence of mural pores and the better developed septa.

It may be a question, however, as suggested by Milne Edwards and Haime, if the form described originally and carefully figured by Goldfuss under the name of *Columnaria alveolata* (Petref. Germ., pl. 24, fig. 7), be not truly an example of *Favistella stellata*, Hall—the specimens seen by Goldfuss being said to come from Seneca Lake, and being, therefore, probably derived from a traveled boulder. The form now universally recognized as *Columnaria alveolata*, and so characteristic of the Trenton limestone, unquestionably has the septa rudimentary and marginal, instead of being well developed and reaching to the center of the corallites, as represented in the figures given by Goldfuss. In any case, however, Hall's genus *Favistella* may be advantageously retained for corals which resemble *Columnaria*, as now accepted, in most essential respects, but differ in the completeness of the septal system and the more thorough amalgamation of the walls of adjacent corallites.

The only species of *Favistella* which appears to occur in the Silurian rocks of Ohio is *F. stellata*, Hall, which is likewise an abundant species in strata of a corresponding age (Hudson River group) in Canada.

FAVISTELLA STELLATA, Hall.

Favistella stellata, Hall; Pal. N. Y., Vol. I., pl. 75, figs. 1a-1c.

Corallum sub-hemispheric, or pyriform, massive; corallites prismatic, usually hexagonal or pentagonal, from rather more than one line to two lines in diameter, completely amalgamated with one another by their walls, except occasionally towards the surface of the mass. Increase by fission of the old tubes. Septa unequally developed, alternately large and small; large septa usually fifteen, sometimes fourteen, in number, reaching to the center of the visceral chamber, or nearly so; small septa marginal and rudimentary. The total number of septa is thus from twenty-eight to thirty. Tabulæ well developed and complete, about three in the space of one line. No columella.

According to Hall, there are usually twelve septa, more or less, in this species; but in this enumeration he has evidently counted only the large septa and disregarded the small ones. The number of large septa, however, is usually fifteen, and the rudimentary secondary septa are placed alternately with the former, and are, therefore, the same in number. In this respect, all the specimens I have examined appear to agree. In the Hudson River group of Canada occurs a species of *Favistella*, which agrees in most respects with *F. stellata*, Hall, but which exhibits the peculiarity that in many examples the corallites are not amalgamated with one

another. On the contrary, the corallites are more or less cylindrical, are disconnected, sometimes placed quite apart, and each provided with a separate epitheca, which is furnished with longitudinal striæ and longitudinal ridges. This may be a separate species, or may be only a variety of *F. stellata*, but I have not yet had the opportunity of examining it sufficiently.

Milne Edwards and Haime, in their great work, not only unite the genera *Favistella* and *Columnaria*, but also regard *F. stellata*, Hall, as being identical with *Columnaria alveolata*, Gold. I have above expressed the opinion that *C. alveolata*, Gold., was originally founded upon examples of *Favistella stellata*, Hall; and the latter name should in this case be undoubtedly abandoned, according to the strict law of priority. In the meanwhile, however, the name of *Columnaria alveolata* has become by general consent firmly fixed upon a very well known and abundant coral from the Trenton limestone, which, in my opinion, is clearly distinct specifically from the coral described by Hall, from the younger deposits of the Hudson River group, under the name of *Favistella stellata*. Whilst, therefore, it may reasonably be doubted if *Favistella* is capable of being generically separated from *Columnaria*, it appears to me that the course which will cause the least confusion is to leave the coral now universally recognized by American palæontologists as *Columnaria alveolata* under this name, retaining the Hudson River form as distinct, and leaving it an open question whether the latter should be called *Favistella stellata* or *Columnaria stellata*. At the same time, as above stated, my own studies of these forms would lead me to think that *Favistella*, though undoubtedly very closely allied to *Columnaria*, may reasonably be regarded as distinct, provided the specimens originally described by Goldfuss under the name of *C. alveolata* be regarded as being erroneously referred to *Columnaria*. If this course should not be adopted, the only alternative will be to redefine the genus *Columnaria* of Goldfuss, so as to make it include *Favistella stellata*, Hall, and to form a new genus for the reception of the so-called *Columnaria alveolata* of the Trenton limestone and its allies.

Position and locality: Hudson River formation (Cincinnati group), Cincinnati, Ohio.

GENUS COLUMNOPORA, Nicholson.

(Geological Magazine, 1874.)

Corallum aggregate, massive, composed of hexagonal corallites, which have distinct walls, but are firmly and inseparably united with one

another. Septa well developed and close set, but short, and not nearly reaching the center of the visceral chamber; a row of large and closely approximated mural pores between each pair of septa; tabulæ horizontal, not vesicular or infundibuliform, apparently imperfect, but probably in reality complete. Epitheca unknown. No cœnenchyma or columella.

I have founded this genus for the reception of a single coral from the Hudson River group of Ohio and Canada, which is intermediate in its characters between *Favosites* and *Columnaria*, resembling both of these genera in its general form, its prismatic, closely approximated corallites, and the absence of any cœnenchyma. *Columnopora* further resembles *Favosites* in possessing mural pores; but it is distinguished by having distinct and well developed septa, and by the fact that the mural pores are arranged in very numerous rows, and are of very large size, so that the walls of the corallites have a regularly cribriform aspect. With *Columnaria*, Goldf., as this genus is generally understood, *Columnopora* agrees in the possession of distinct septa; but it is fundamentally distinguished by the perforated walls of the corallites. With *Favistella*, Hall, the present genus agrees in form, in the possession of septa, and in the amalgamation of the walls of the corallites; but it is separated by the presence of mural pores, and by the fact that the septa, though very distinct, are marginal, and do not nearly reach the center of the visceral chamber of the corallites.

COLUMNOPORA CRIBRIFORMIS, Nicholson.

Plate 2, figs. 8, 8b.

Columnopora cribriformis, Nicholson; Geol. Mag., 1874.

Corallites mostly hexagonal or pentagonal, averaging about one and a half lines in diameter, sometimes more or less. Septa in the form of strong vertical ridges, from twenty to twenty-four in number, equally developed, never reaching the center, but only extending quite a small distance into the interior of the corallites. Between each pair of septa is a row of large, oval, or circular mural pores, so that there are from twenty to twenty-four rows of these openings on each corallite, generally four rows upon each face. Not only are the rows very numerous, but the pores are extraordinarily large, and are placed close together, about three of them occupying the space of one line, measured either vertically or transversely. The intervals between the pores are extremely slender,

and the walls of the corallites thus assume a completely cribriform appearance, looking as if composed of a series of vertical pillars (the septa) united by horizontal crossbars. Tabulæ, in the specimens observed, imperfect; from three to four in the space of one line.

The examples of this species that have come under my notice form pyriform or sub-spherical masses, sometimes of considerable size. Superficially, they nearly resemble the coral which is generally recognized as *Columnaria alveolata*, both in the general form of the corallites and the dimensions and characters of the septa, but they are sufficiently distinguished by the mural pores. From all the massive species of *Favosites* the present species is distinguished by the well marked septa, and the large size and great number of the pores. From *Michelinia*, again, *C. cribriformis* is separated by not having vesicular tabulæ, by the larger and more closely set mural pores, and by the better developed septal system.

In all the specimens I have seen, the tabulæ are incomplete, and nothing is left of them but their bases. This state of things, however, is quite common in examples of *Favosites* and *Columnaria*, and I entertain no doubt but that the tabulæ of the present form were in reality complete and in all respects well developed.

Position and locality: Cincinnati group, near Cincinnati, Ohio (collected by Mr. U. P. James); also in rocks of the same age (Hudson River group), River Credit, Canada.

GENUS CHÆTETES, Fischer, 1837.

(Oryct. du Gt. de Moscow, p. 160.)

The genera *Chætetes*, Fischer, *Stenopora*, Lonsdale, and *Monticulipora*, D'Orb., comprise a great number of highly characteristic Palæozoic Corals, which agree with *Favosites* in possessing a corallum made up of prismatic or sub-cylindrical corallites, without septa, or with these structures in a rudimentary form, but with a well developed system of transverse diaphragms or tabulæ. From *Favosites* the above-mentioned three genera are readily distinguished by the absence of mural pores, but their separation from each other is a much more difficult matter. As originally defined by Fischer, the genus *Chætetes* was separated from *Favosites* only by the supposed absence of tabulæ in the former; but Mr. Lonsdale, with his usual acumen, pointed out that the type species of the genus (*C. radians*, Fischer) was characterized by the amalgamation of the walls of contiguous corallites, a peculiarity depending upon their fissiporous mode of increase "by sub-divisions within the area of the parent tube." This

peculiarity is stated to be recognizable in practice by the fact that a rough fracture of the coral exposes the interior of the tubes, instead of bringing the exterior of the corallites into view, and it is remarkably well shown in the figures of *C. radians*, given by Lonsdale. (Geology of Russia in Europe, Appendix, pl. A, fig. 9a.) Subsequent palæontologists have for the most part accepted this distinction, and it was chiefly on account of this character that Mr. Lonsdale proposed the genus *Stenopora*, and M. D'Orbigny that of *Monticulipora*, for corals in other respects essentially similar to the type forms of *Chætetes*. I have elsewhere discussed this question at greater length, and shall simply remark here that I find it impossible to accept this distinction in the meanwhile as separating the genera *Chætetes* and *Monticulipora*, whilst the genus *Stenopora*, though very possibly to be retained for the forms originally placed under it, can not with propriety be held to include the corals generally referred to it by European palæontologists. Apart from other grounds, it appears to me that this course is unavoidable, if only upon the ground that the distinction by which it is sought to separate the genera *Chætetes* and *Monticulipora* is one which can only very rarely be applied in practice with any certainty. Many corals which would have to be referred to one or other of these genera are so minute as to render the determination of their mode of growth a matter of the utmost difficulty, if not an absolute impossibility, whilst the results yielded by *fracture* of the coral are by no means invariable, the same species splitting in such a manner as at one time to show the interior of the corallites, and at another time the exterior. In illustration of the difficulty which the best observers may find in determining the mode of growth of these corals, it may be mentioned that the familiar *Chætetes petropolitanus*, Pander, is stated by Lonsdale to divide fissiporously, and to be referable to the genus *Chætetes*, as restricted by him. On the other hand, the very common coral which American palæontologists have almost unanimously recognized as being *Chætetes petropolitanus*, Pander, increases by gemmation, a rough fracture almost always exhibiting the *exterior* of the corallites, so that it would thus have to be placed in either *Monticulipora* or *Stenopora*. Hence it would appear that some more satisfactory distinction must be pointed out before we can with certainty separate the genera *Chætetes* and *Monticulipora*, since these are not supposed to differ in any character of importance except their mode of growth.

The genus *Stenopora*, Lonsdale, has not uncommonly been quoted by American palæontologists, but I have seen no specimens which could properly be referred to it. It is defined by Mr. Lonsdale as follows: "A ramose, spherical, or amorphous, tubular polypidom; tubes polygonal or

cylindrical, radiated from a center or an imaginary axis, contracted at irregular distances, but in planes parallel to the surface of the specimen; tubular mouths closed at final period of growth; ridges bounding the mouths, granulated or tuberculated; additional tubes interpolated." (Physical Description of New South Wales, Stryzelecki, p. 262, 1845.) I have already pointed out that the mode of growth is a character which can only occasionally be recognized in practice, and, at any rate, in this character *Stenopora* does not differ from *Monticulipora*. Leaving this out of the question, therefore, the distinctive characters of *Stenopora* are to be found in the granulated, tuberculated, or spinose mouths of the corallites, the final closure of the calices, and the constrictions of the corallites in planes parallel to the surface. Two or three species of *Chætetes*, from the Palæozoic deposits of North America, exhibits tuberculated or spinose margins to the calices, but none of them exhibit the other characters of *Stenopora*, and I have, therefore, come to the conclusion that none of our forms can be referred to this genus.

For the reasons above given, then, I shall consider all the corals here referred to as belonging to the genus *Chætetes*, irrespective of the fact that many of them have been formerly placed by eminent palæontologists under the genus *Monticulipora*, and others of them have been put under *Stenopora*. The Lower Silurian deposits of Ohio have yielded a magnificent series of corals of this nature—a series which is remarkable not only for the wide range of specific variation which it exhibits, but also for the vast abundance of individuals belonging to the commoner species, and the great beauty and perfection of their preservation in very many instances. From their small size, the characters which separate many of the species are necessarily minute and difficult of detection, except by the exercise of considerable care, and by the comparison of a number of specimens with one another. Some of the species hereafter described are very nearly allied to one another, and in other instances individual specimens may be found which seem to stand midway between two species, and can not readily or definitely be referred to either. This would give countenance to the belief that future researches might ultimately enable us to unite some of these so-called species under one or more highly variable specific types. Nevertheless, it seems clearly necessary, on behalf of the working palæontologist, to give separate titles to these nearly allied forms, and the drawbacks which notoriously attend the placing of many varieties under a single species render it advisable, in practice, to make these titles of specific value.

The different species of *Chætetes*, in the wide sense here understood, may be conveniently, if not altogether in accordance with nature,

divided into the four following groups, a single species being apparently sometimes, though certainly very rarely, represented by examples belonging to two groups:

A. RAMOSE SPECIES.—Corallum ramose, or dendroid, the corallites springing in a radiating manner from an imaginary axis. The base rooted, the extremities of the branches rounded. Some of the forms of this group are slender; others are more or less swollen and tumid; and these latter appear to form a transition between the former and certain lobate examples, which may be variously regarded as the last term of the ramose group or the first term of the massive group. The species of *Chætetes* belonging to this section which I have recognized in the Silurian rocks of Ohio are *C. Dalei*, Edw. and H., *C. rugosus*, Edw. and H., *C. approximatus*, Nich., *C. attritus*, Nich., *C. pulchellus*, Edw. and H., *C. Fletcheri*, Edw. and H., *C. gracilis*, James, *C. delicatulus*, Nich., *C. nodulosus*, Nich., *C. Jamesi*, Nich., *C. rhombica*, Nich., *C. sub-pulchellus*, Nich., *C. briareus*, Nich., and *Chætetes sigillarioides*, Nich.

B. MASSIVE SPECIES.—Corallum fixed or free; the form very variable, most commonly concave convex or discoidal, hemispherical or nearly spherical, sometimes lobate or altogether irregular in shape. The typical forms of this group have the under surface of the corallum covered by an epitheca, and as this surface is more or less deeply concave, such forms must have lived a free existence. Others are fixed to some foreign object, and the mode of existence of some examples is uncertain. I have recognized in the Silurian rocks of Ohio, as belonging to this section of *Chætetes*, the following species: *C. petropolitanus*, Pander, *C. discoideus*, James, and *C. filiasa*, D'Orb. (?).

C. FRONDESCENT SPECIES.—Corallum forming a flattened or undulated expansion, often sub-palmate or palmate, rooted at the base, but covered over the entire surface on both sides by the openings of the corallites. The corallum primitively consists of two layers of corallites, the bases of which are opposed to each other, and which are directed in opposite directions from a common calcareous membrane. In old examples, however, additional strata of corallites may be superimposed upon the two primordial layers. In very rare instances the corallum becomes massive, apparently by the folding of the expansion and its reduplication upon itself, or by the production of successive layers of corallites. The Silurian strata of Ohio have yielded of this section *C. mammulatus*, Edw. and H., *C. frondosus*, D'Orb., and *C. (?) clathratulus*, James.

D. ENCRUSTING SPECIES.—Corallum forming a thin crust, which consists primitively of a single layer of corallites, and which is parasitically attached to the shells of Brachiopods, Cephalopods, or other molluses, or

to the exterior of other corals. This section of the genus is an exceedingly natural one, and there is no reason to suppose that there is any transition between it and any of the preceding groups. It is represented in the Silurian deposits of Ohio by *C. papillatus*, McCoy, *C. corticans*, Nich., *C. Ortoni*, Nich., *C. Newberryi*, Nich., and *C. petechialis*, Nich.

CHÆTETES DALEI, Edwards and Haime.

Plate 21, figs. 1, 1a.²

Chætetes Dalei, Edwards and Haime; Pol. Foss. des Terr. Pal., p. 266, pl. 19, fig. 6.

Monticulipora Dalei, Edwards and Haime; Brit. Foss. Corals, p. 265, note.

Corallum branching, the stems cylindrical or elliptical, dividing dichotomously at short intervals, sometimes reticulating, their average diameter when full grown from three to four lines, but when immature from one line to two lines. Calices in general six to eight in the space of one line, polygonal, with moderately thick walls. A greater or less number of exceedingly small calices always intercalated among the ordinary corallites. Surface covered with conical, often sharply pointed, rarely transversely elongated eminences or tubercles, which sometimes attain a height of more than half a line, and which are placed at distances apart of from half a line to nearly one line. Commonly these eminences are arranged in irregular diagonal lines, and they are always occupied by corallites which do not exceed the average in point of size. The summits of the tubercles, indeed, are not unfrequently solid, or are occupied by corallites of less than the average size.

The typical examples of this well marked and common species are distinguished by the prominence of the closely arranged surface-tubercles, which are exceedingly conspicuous, and are not drawn out into transverse ridges, whilst the normal or average corallites are separated by a great number of extraordinarily minute cylindrical corallites. The larger sized tubes are thus surrounded by from three to six or more of these intercalated tubuli, and they thus acquire a more or less circular form. In other examples, however, which approach *Chætetes approximatus*, Nich., the tubercles are not so pronounced nor so sharply elevated; whilst the corallites only exhibit a few minute tubuli placed occasionally at their angles of junction. In both forms the branches are not uncommonly hollow, and it is not very rare for a certain amount of anastomosis to take place between contiguous branches.

Locality and position : Cincinnati group, Cincinnati, Ohio.

CHÆTETES RUGOSUS, Edwards and Haime.

Plate 21, fig. 2.

Chætetes rugosus, Edwards and Haime; Pol. Foss. des Terr. Pal., p. 268, pl. 20, fig. 6.
Monticulipora rugosa, Edwards and Haime, Brit. Foss. Corals, p. 265, note.

Branches cylindrical or flattened, from two to three lines in diameter, dividing dichotomously at short intervals. Corallites polygonal or sub-circular, the average ones varying from six to eight in the space of one line, separated by many exceedingly minute interpolated cylindrical tubuli. Surface exhibiting numerous elevations, which have a height of from one-fourth to one-half line, and are transversely elongated, so as to constitute so many discontinuous transverse ridges. These ridges vary in length, but they do not extend quite round the stems, and they are usually sharp-edged, and placed about half a line apart. The corallites upon these ridges are not larger than those on the other parts of the coral.

This species is in many respects most closely allied to *C. Dalei*, and there is a considerable probability that a series of intermediate forms may ultimately be obtained by which the two species may be united. The present species is distinguished from the preceding chiefly by the elongation of the surface tubercles in a direction transverse to the long axis of the branches; but in addition to this character there is here an even greater development of the system of minute tubuli between the ordinary corallites than is seen in *C. Dalei*.

Locality and position: Cincinnati group, Cincinnati, Ohio.

CHÆTETES APPROXIMATUS, Nicholson.

Plate 21, fig. 3.

Corallum composed of cylindrical stems, from one and a half to nearly three lines in diameter, dividing dichotomously at short intervals. Corallites tolerably thick-walled, oval, sub-circular, or polygonal in shape, from eight to ten in the space of one line, often with excessively minute corallites interspersed amongst them, though these are rarely as abundant as in the preceding forms, and may be nearly absent. Surface exhibiting a number of small conical or somewhat transversely elongated eminences, which are very slightly elevated above the general surface. These eminences are placed in irregular diagonal rows, separate about

half a line transversely and two-thirds of a line measured vertically, and they are either solid at their summit, or carry a few excessively small cylindrical tubuli, with or without one or more of the ordinary corallites.

This form is very readily distinguished from the typical examples of *C. Dalei*, Edw. and H., by the slightly smaller calices, the smaller number of the intermediate tubuli, and the characters of the surface tubercles, which are not conical or prominent, and which are not covered with corallites of the ordinary size. Nevertheless, I do not feel sure that *C. approximatus* can be regarded as more than a very distinct variety of *C. Dalei*, to which it is certainly closely allied, and to some forms of which it presents a very close resemblance.

Locality and position: Cincinnati group, Cincinnati, Ohio. Collected by Mr. U. P. James.

CHÆTETES ATTRITUS, Nicholson.

Plate 21, fig. 4.

Corallum composed of sub-cylindrical branches, which divide at short intervals, and have a diameter of from four to seven lines. Corallites with thin walls, sub-equal, polygonal, from eight to ten in the space of one line. Some of the corallites are smaller than the others, but there is apparently a complete, or almost complete, absence of excessively minute tubuli interspersed amongst the larger tubes. Surface exhibiting numerous minute, solid, quadrangular, or conical eminences, placed at the point of junction of five or six corallites, and not carrying any cells themselves. These singular prominences are usually closely set, four or five of them occupying the space of one line.

This species is distinguished from all the preceding forms by its thin-walled corallites, the absence of very minute tubules intercalated amongst the ordinary corallites, and the minute, crowded, solid prominences with which the surface is studded. At first sight, I was disposed to think that its peculiar appearance might be due to weathering, and that it might really be referable to some other species. A close examination of the specimens, however, has induced me to reject this view.

Locality and position: Cincinnati group, Cincinnati, Ohio. Collected by Mr. U. P. James.

CHÆTETES PULCHELLUS, Edwards and Haine.

Plate 21, figs. 5, 5a.

Chætetes pulchellus, Edwards and Haine; Pol. Foss. des Terr. Pal., p. 271.*Monticulipora pulchella*, Ibid; Brit. Foss. Corals, p. 267, pl. 62, fig. 5.

Corallum very variable in form, usually of sub-cylindrical or compressed branches, which have a diameter of from two to six lines, sometimes forming flattened, expanded, and sub-palmate stems, sometimes inosculating and reticulated. Corallites thin-walled, polygonal, unequal in size, the ordinary ones averaging about eight in the space of one line. Surface exhibiting rounded or somewhat stellate groups of large sized corallites, which are usually almost twice as large as the average, two or three occupying the space of half a line, and which sometimes have very minute cylindrical corallites interspersed between them. These groups of larger corallites generally comprise from five to seven or more individuals, and they are generally very slightly elevated above the general surface, so that any tuberosities which may exist are slight, rounded, and inconspicuous. Usually the groups of large corallites are placed at distances apart of about one line.

The typical examples of *C. pulchellus*, E. and H., can be very readily recognized by the well marked groups of large sized corallites interspersed amongst those of average size, the groups often being slightly elevated above the general surface, but not occupying conspicuous tubercles. Moreover, the corallites are thin-walled, usually hexagonal, and rarely exhibiting any very minute intercalated tubuli. Nevertheless, *C. pulchellus* affords an excellent instance of the enormous difficulty which the observer has to encounter when he examines an extensive *suite* of specimens of these corals, and would endeavor to separate one form from others nearly allied to it. So great is this difficulty that it must be understood that no absolute assertion is made by me as to the real distinctness of some of the forms here described under distinct names. I have had the opportunity of examining very extensive collections of these corals, and have been enabled to separate certain examples which present characters sufficiently distinct to be recognized without difficulty by the practiced observer, but I am far from asserting that still more extensive collections might not show a graduated series of intermediate forms uniting the several apparently distinct types with one another. As regards *C. pulchellus*, at any rate, it is certain that, whilst type specimens of the species can be recognized without the

smallest difficulty, it is a matter of impossibility to determine, with the materials at present in our hands, what are the true limits of the species. Thus, specimens apparently belonging to *C. pulchellus* may be picked out which approximate to *C. approximatus*, Nich., and which thus tend towards the type of *C. Dalei*, Edw. and H., since they possess tolerably distinct surface tubercles. Others approach *C. Fletcheri*, Edw. and H., so nearly, that it becomes absolutely out of the question to draw a rigid line of demarkation between the two species, certain specimens being just as properly referred to the one as to the other. In this way *C. pulchellus* is brought into direct connection with *C. gracilis*, James, though typical examples of the two species could not be confounded with one another for a single instant. Again, the forms which I have here separated under the name of *C. sub-pulchellus* form an unmistakable transition between *C. pulchellus*, in its proper form, and *C. mammulatus*, Edw. and H., the latter belonging to the frondescant and laminated section of the genus. In spite, however, of the close relationships thus indicated, it seems in the meanwhile expedient to give separate titles to such forms as admit of ready identification, leaving it for future determination whether these forms are in reality entitled to rank as distinct species, or whether they may be merely different phases of one very variable species.

Locality and position : Cincinnati group, Cincinnati, Ohio.

CHÆTETES SUB-PULCHELLUS, Nicholson.

Plate 21, figs. 6, 6a.

Corallum branched, the branches usually hollow, always more or less compressed, and sometimes so much flattened as to become frondescant. Greatest diameter of the branches, from four lines to nearly an inch. The average corallites are circular or polygonal in form, with comparatively thin walls, about eight in the space of one line, with or without a few very minute cylindrical tubuli interspersed amongst them. Intercalated amongst the ordinary corallites are rounded or sub-stellate spaces, about one line in diameter, and placed nearly one line apart, which are occupied by tubes of two kinds. The exterior of each of these spaces is formed by a ring of corallites which are slightly larger than the average, about six of them occupying one line. Inside this ring is a series of from twenty to forty excessively small cylindrical tubuli, forming a little cluster of pin-like punctures or perforations. The composite clusters of large and small corallites thus constituted are very slightly or not at all elevated above the general surface, and they melt away insensibly at their margins into the ordinary corallites.

This species is closely allied to *C. pulchellus*, Edw. and Haime, but appears to be distinguished sufficiently from it by the flattened and compressed form of the branches, and the composite character of the hardly elevated tubercles, which do not consist throughout of large sized corallites, but have an external ring of large tubes surrounding an internal cluster of very minute tubuli. I have found these characters constant in a large number of individuals, and consider, therefore, that I am justified in describing this form under a distinct title.

The above description is founded upon specimens collected by Prof. Edward Orton and Mr. U. P. James, and kindly submitted to me for examination.

Locality and position: Cincinnati group, Cincinnati, Ohio.

CHÆTETES FLETCHERI, Edwards and Haime.

Plate 21, figs. 7, 7a.

Culamopora spongites ? var. Goldfuss, Petref. ; pl. 64, fig. 10 (in parte).

Favosites spongites (pars) Lonsdale; Sil. Syst., pl. 15 *bis.*, figs. 9, 9a, 9b (cæt. excl.).

Chætetes Fletcheri, Edw. and Haime; Pol. Foss. des Terr. Pal., p. 271, 1851.

Chætetes lycoperdon, Hall (pars); Pal. N. Y., Vol. II., pl. 17, figs. 1g-i (cæt. excl.).

Monticulipora Fletcheri, Edw. and Haime; Brit. Foss. Corals, p. 267, pl. 62, figs. 3, 3a.

Corallum ramose, branches cylindrical, or sub-cylindrical, dividing dichotomously at remote intervals, often irregularly swollen at short distances, from one and a half to three lines in diameter, not uncommonly hollow. Corallites circular or oval, with comparatively thick walls, unequally sized, those of average dimensions being from eight to ten in the space of one line. Interspersed with the ordinary corallites are exceedingly minute cylindrical or polygonal tubuli, sometimes in small numbers, and at other times in great plenty. Surface smooth and entirely destitute of elevations or tubercles, but occasionally showing groups of corallites the size of which is very slightly larger than the average.

The examples of *C. Fletcheri*, which I have examined from the Clinton group of Canada, agree entirely with the description given by Edwards and Haime, being smooth, and simply having very minute corallites intercalated amongst those of ordinary size. On the other hand, most of the examples of this species which I have seen from the Lower Silurian strata of Cincinnati, though also smooth, and also having minute tubules interspersed amongst the larger corallites, exhibit distinct groups of cor-

allites, which are of rather larger size than the average, but which are not set upon distinct elevations. They thus approach *C. pulchellus*, Edw. and H., from which they are distinguished chiefly by the fact that the corallites of the groups in question exceed the average corallites in point of size only very slightly, and not to such an extent as to constitute a conspicuous feature. Other specimens from the Cincinnati group, which are apparently referable to this species, do not exhibit any large sized corallites beyond an occasional individual here and there, and these examples have such a large number of minute tubuli surrounding the ordinary corallites that I was at first disposed to consider them as a distinct species. In many respects, *C. Fletcheri* very nearly approaches *C. gracilis*, James, but the latter species is usually branched at shorter intervals and at more acute angles, whilst the corallites are much more oblique to the surface, and the calices are on an average decidedly smaller.

There appears to be no doubt but that *C. Fletcheri* is in part identical with *C. lycoperdon*, Hall; but so many forms have been included under this name that it seems impossible to retain it for any one of them.

Position and locality: Cincinnati group, Cincinnati, Ohio.

CHÆTETES GRACILIS, James.

Plate 21, figs. 8, 8b.

Chætetes gracilis, James (named but not figured or described). Catalogue of the Fossils of the Cincinnati Group, 1871.

Corallum dendroid, the branches solid or hollow, cylindrical or sub-cylindrical, dividing dichotomously at short intervals and at very acute angles (usually from 25° to 40°), from less than one line to two lines or more in diameter. Corallites very small, from ten to twelve in the space of one line, opening obliquely on the surface by oval or sub-triangular calices, the walls of which are separated by very distinct lines of demarcation, and between which are placed more or fewer very minute tubuli. The surface shows no elevations or tubercles, but is entirely smooth, and altogether destitute of any groups of large-sized corallites. The margins of the calices are sometimes finely granulated. This species may in general be distinguished by the oval, or rounded, thick-walled calices, and the minute dimensions of the ordinary corallites, together with the marked obliquity of the corallites to the surface, and the very acute angle at which the stems bifurcate. These characters, together with the entire absence of any corallites of larger size than the average, sufficiently separate *C. gracilis* from *C. Fletcheri*, with which it is, however, very closely

allied. From *C. delicatulus*, Nich., with which it is also related, *C. gracilis* is separated by the smaller obliquity of the corallites, and the presence of minute interstitial tubes between the ordinary corallites. The above description is drawn from type specimens kindly furnished for examination by Mr. U. P. James.

Locality and position: Cincinnati group, Cincinnati, Ohio.

CHÆTETES DELICATULUS, Nicholson.

Plate 21, figs. 9, 9a.

Corallum very slender and delicate, ramose, of cylindrical stems, which terminate sometimes in thickened, rounded extremities, and which in some cases appear to spring from a horizontal foot-stalk. Stems sometimes simple, more commonly branched, the divisions taking place dichotomously at acute angles. Diameter of the stems usually about half a line, sometimes a quarter of a line, rarely two-thirds of a line. Corallites very oblique to the surface of the coral, opening by oval apertures, the length of which corresponds with the long axis of the stem and uniformly exceeds the breadth. Calices in diagonal rows, about eight in one line, measured longitudinally, and twelve to fourteen in the same space measured diagonally. The calices are all of equal size, and when perfect the lower lip is more or less thin and prominent. The surface is entirely devoid of monticules or elevations of any kind, and there are no very minute tubuli amongst the ordinary corallites.

This is one of the commonest fossils of the Hudson River group, both in the United States and in Canada, and it is probably identical with one of the forms figured by Hall from the Trenton limestone under the name of *C. lycoperdon* (Pal. N. Y., Vol. I., pl. 24, fig. 1k, (cæt. excl.). From its very minute size, I am left in doubt as to the true position of this abundant little fossil. It is, I think, certainly a *Chætetes*, and not a *polyzoon* allied to *Helopora*, Hall; and it is most probably the form which has usually been quoted as a slender variety of *Stenopora fibrosa*, though its characters would in any case forbid its being retained in this position. It most closely resembles *Chætetes gracilis*, James, of which it might be supposed to be only a small variety; but it is separated by not possessing any minute tubuli interspersed amongst the ordinary corallites, by the much greater obliquity of the tubes, by the greater thinness of the walls of the corallites, and by its uniformly slender habit and stunted growth. From *C. Fletcheri*, Edw. and Haime, it is at once dis-

tinguished by the entire uniformity in the size of the corallites, and their much greater obliquity as regards either the surface or the imaginary axis of the stems.

Locality and position: Abundant in the upper part of the Cincinnati group, Ohio.

CHÆTETES NODULOSUS, Nicholson.

Plate 21, figs. 10, 10a.

Corallum minute, dendroid, of small cylindrical stems, which vary from two-thirds of a line to one line in diameter, and branch dichotomously at intervals of about two lines. The corallites are prismatic, or hexagonal, or sub-cylindrical, directed somewhat obliquely to the surface, of two sizes. Larger corallites opening by oval or sub-circular apertures, the long diameters of which correspond with the axis of the stem, from six to eight in the space of one line, measured vertically. The large sized corallites are surrounded in turn by exceedingly minute circular tubuli. Surface exhibiting numerous minute elevations or tubercles, which are sometimes conical, sometimes transversely elongated, and are placed at distances of about half a line apart, thus communicating to the stems a characteristically nodulose appearance.

This very distinct form is most closely allied to *C. Dalei*, Edw. and Haime, but is readily separated by its much more slender and graceful proportions, and the smaller size of the comparatively much more remote tubercles. One specimen, which would appear to be referable here, exhibits on transverse section about twelve distinct radiating septa meeting in the center of each of the corallites. All the examples possess tabulæ, and are quite like the other forms of *Chætetes* in their general characters; but if it should be shown by subsequent investigations that radiating septa are present in addition, the species will have to be removed from this conjunction and placed elsewhere.

Locality and position: Cincinnati group, Clermont county, Ohio.

CHÆTETES JAMESI, Nicholson.

Plate 21, figs. 11, 11a.

Corallum of cylindrical or sub-cylindrical, usually hollow branches, the diameter of which is from three to five lines, or of lobate or sub-palmate masses, the extremities of which are rounded. Branches, in the ramose

examples, dividing dichotomously at varying intervals, irregularly thickened and nodulated. Corallites oval, circular or sub-polygonal in section, of unequal sizes. The larger corallites are about six in the space of one line, with extremely thick walls, the margins of the oval or rounded calices being generally obscurely tuberculated or granulated. The large corallites are occasionally separated by extremely minute cylindrical tubuli, which vary in number in different specimens or in different parts of the same specimen, their presence, however, usually being little conspicuous. The surface exhibits no eminences or tubercles of any kind, nor are there any groups of large sized corallites; but typical specimens exhibit at irregular intervals stellate spaces, which are either solid or minutely punctate, and which have a diameter of about two-thirds of a line.

This species is very nearly allied to *Chætetes tumidus*, Phillips, especially in the rounded and thickened corallites, separated by minute cylindrical tubules. *Chætetes Jamesi*, however, is distinguished by the larger size and greater thickness of the ordinary corallites, by the smaller development of the system of minute intermediate tubuli, the obscurely tuberculated margins of the calices, and the general existence of stellate, solid or pitted, vacant spaces. The value of the last of these characters is diminished by the fact that some specimens, in other respects the same, do not exhibit these spaces in a conspicuous manner. Even in the absence of these, however, the species can very readily be recognized by the extraordinary thickness of the walls of the corallites, in which respect it is not approached by any other form which occurs in the Lower Silurian rocks.

I have named this species in honor of Mr. U. P. James, who has collected the organic remains of the Cincinnati group with the greatest perseverance and judgment, and who kindly furnished me with specimens for examination.

Locality and position: Cincinnati group, Cincinnati, Ohio.

CHÆTETES RHOMBICUS, Nicholson.

Plate 21, figs. 12, 12a.

Corallum ramose, the stems hollow or solid, sub-cylindrical, from four to six lines in diameter, terminating in acutely pointed, or, at other times, in swollen and bulbous extremities. Corallites with very thin walls, about eight or ten in the space of one line, variable in form and

arrangement. In parts of the corallum the calices are regularly hexagonal, but over the greater portion of the surface they are obliquely rhombic, and are arranged in regular diagonal lines, the direction of which, however, changes repeatedly within short distances, giving to the corallum a most peculiar appearance. In any portion of the corallum in which this arrangement obtains, the calices are arranged in a double series of curved or nearly straight diagonals, the one set crossing the branch transversely, whilst the other series is nearly vertical and corresponds more or less with the axis of the stem. The corallites are nearly equal in size, and there are no very minute tubuli interspersed amongst the average ones. Occasionally a few corallites occur which are slightly larger than the average, but the surface exhibits no tubercles nor any regular groups of large sized corallites.

This species is related somewhat to *Chætetes* (*Monticulipora*) *Bowerbanki*, Edw. and Haime, but it differs in its simply ramose mode of growth, especially when young, and especially in the much smaller size of the corallites, which are only about half as large.

Locality and position: Upper part of the Cincinnati group, Ohio. Collected by Mr. U. P. James.

CHÆTETES BRIAREUS, Nicholson.

Plate 21, figs. 13, 13b.

Corallum free (?), commencing in a pointed base which does not show any indication of having been at any time attached to any foreign body. Above the base the corallum expands so as to form an inverted and somewhat compressed cone. From the top of this cone proceed in one specimen four cylindrical branches, which almost immediately divide each into two branches, thus giving rise to eight vertical, slender stems, which have a diameter of two lines each. The further course and final termination of these branches is not shown, as the specimen is unfortunately broken at this point. In another specimen the basal cone gives off only two branches from its summit. These bifurcate, and the branches thus produced bifurcate again, two of the tertiary branches inosculating directly above the basal cone. In this specimen, also, the branches are all broken just above their origin, and their terminations thus remain unknown. Surface smooth, destitute of tubercles, but showing here and there small and irregular groups of corallites, which are very slightly larger than the average. Corallites thick-walled, about eight or ten in the space of one line, entirely without intermediate minute tubuli. Calices oval or circular.

I have only seen two specimens of this interesting coral, both broken and imperfect as regards the terminations of the branches. In the best of these specimens the entire height, so far as preserved, is one inch and a half, of which the basal cone occupies nine lines. The width at the point where the branches come off is nine lines, and the thickness of the corallum at the same point is five lines.

This singular form is so remarkable in its shape and mode of growth that I have no hesitation in separating it from all previously recorded species. At the same time its minute characters show no special peculiarity by which a mere fragment could be distinguished from *C. pulchellus* or *C. Fletcheri*, E. and H., if we except the fact that the corallites have walls of more than usual thickness when well preserved, whilst there is an entire absence of the minute intercalated tubuli so common in the above-mentioned species. The corallum in *C. briareus*, judging from its sharply pointed and slightly curved base, would appear to have been free, but we have no means of settling this point with absolute certainty.

The above description is drawn from specimens kindly submitted to me for examination by Mr. U. P. James, of Cincinnati.

Position and locality: Cincinnati group, near Cincinnati, Ohio.

CHÆTETES SIGILLARIOIDES, Nicholson.

Plate 22, figs. 9, 9a.

Corallum ramose, of small dichotomously dividing branches, the diameter of which is rather over one line. Calices regularly oval or sub-circular, their longer diameter corresponding with that of the stems, arranged in diagonal lines, about six in one line, measured diagonally, and from four to five in the same space, measured vertically. Between the average calices are a few minute sub-cylindrical tubuli. In the center of each calice, as a general rule, is a small, circular, secondary calice, about half the diameter of the main calice, and surrounded by a distinct wall, the general appearance of the calices thus somewhat resembling the markings of *C. Sigillaria*. Walls of the corallites thin. Surface smooth, or with a few low, scattered, and irregular tuberosities, which in no way differ from the general surface, and always form a quite inconspicuous feature.

As a general rule, fragments of this species can be recognized with the greatest ease by the peculiar appearance due to the existence of small circular calices within the main calices. In parts of some of the speci-

mens, however, these secondary calices appear to be absent, and then the species is recognizable by its large, oval, thin-walled calices, arranged in diagonal rows, and separated by minute tubuli, its smooth surface, and its small dimensions. Whether the appearance of secondary calices is due to the formation of perforated diaphragms over the mouth of the tubes at their final period of growth or not, I am not prepared to say.

Position and locality: Cincinnati group, Cincinnati, Ohio. From the collection of Mr. U. P. James.

CHÆTETES PETROPOLITANUS, Pander.

Plate 21, figs. 14-14b.

Favosites petropolitanus, Pander; Russ. Reiche, pl. I, figs. 6, 7, 10, 11 (1830).

Calamopora fibrosa (pars), Goldf.; Petref., pl. 64, fig. 9.

Favosites hemisphericus, St. Kutorga; Zweit. Beitr. zur Geogn. and Palæont., pl. 8, fig. 5, and pl. 9, fig. 3.

Calamopora fibrosa, Eichwald; Sil. Syst. in Esthl., p. 197.

Favosites lycoperdon, Lardner Vanuxem; Geol. of New York, 3d Part, p. 46, fig. 3.

Chætetes petropolitanus, Lonsdale, in Murch. Vern. and Keys; Russ. and Ural., Vol. I., p. 596, pl. A, fig. 10.

Favosites petropolitana, McCoy; Syn. of the Silur. Foss. of Ireland, p. 64, pl. 4, fig. 21.

Chætetes lycoperdon, Hall (pars); Pal. N. Y., Vol. I., p. 64, pl. 23, fig. 1, and pl. 24, figs. 1a-f; Vol. II., p. 40, pl. 17, figs. 1a-f.

Chætetes rugosus, Hall; Pal. N. Y., Vol. I., pl. 24, fig. 2.

Chætetes petropolitanus, *lycoperdon*, and *sub-fibrosus*, D'Orbigny; Prodr. de Palæont., Vol. I., pp. 25 and 108.

Chætetes petropolitanus, Edwards and Haime, Pol. Foss. des Terr. Palæoz., p. 263.

Monticulipora petropolitana, Edwards and Haime, Brit. Foss. Corals, p. 264.

Chætetes petropolitanus?, Meek and Worthen; Geology of Illinois, Vol. III., p. 304, pl. 2, fig. 8 a, b.

"Corallum in general free; its basal plate flat or concave, and completely covered with a thin concentrically wrinkled epitheca. Upper surface regularly convex, in general hemispherical, and presenting obtuse tuberosities, about one line broad and varying very much in height. In some specimens these tubercles appear to have worn away, and their existence is indicated only by the presence of small groups of large calices, with thick walls; the calices are rather unequal in size, generally polygonal, sometimes almost circular; the largest are about one-fifth of a line in diameter; the walls are not perforated. The tabulæ are horizontal, complete, and placed about one-twelfth of a line from each other. Some vestiges of septa are often visible. Young specimens

are flat and discoidal." (Milne Edwards and Haime, Brit. Foss. Corals, p. 265.)

The Cincinnati group of Ohio, in common with the Trenton and Hudson River formations elsewhere, yields a great many examples which correspond with the above description in all essential respects—some altogether so, others with more or less striking variations. In form this species is protean, being more or less discoidal when young, but being, in the adult condition, sub-spherical, spherical, sub-pyriform, lobate, mushroom-shaped, or not uncommonly resembling a cardinal's hat in figure. The surface is sometimes mammillated with obtusely rounded tubercles or elevations of variable height; but quite commonly the surface is perfectly smooth. Definite groups of large sized corallites are often present, but also can often not be recognized. In all the specimens I have examined the calices are polygonal or sub-polygonal, generally from eight to ten in one line, and without any very minute tubuli interspersed amongst them.

The young forms of *C. petropolitanus* have in their most typical condition the form of circular discs, flat or concave below, and more or less strongly elevated and hemispheric above, a specimen six lines in diameter having a thickness in the center of three lines.

Besides the typical free-living examples of this species, with a flat or concave base, and a concentrically wrinkled epitheca, the Cincinnati group yields a number of massive lobate examples, which may be regarded as making an approach to *C. pulchellus*, E. and H., which they strongly resemble in the characters of the surface and the corallites.

Lastly, we meet with a number of smaller or larger, nodulated, hemispherical, sub-spherical, or irregular masses, which agree with the typical examples of this species in most respects, but of which some are covered with corallites over their entire surface, whilst others are attached parasitically to foreign bodies, and have therefore no concave under surface. In the meanwhile, however, it does not seem advisable to separate these forms from *C. petropolitanus*.

I am disposed to think that *Lichenalia concentrica*, Hall, has been founded upon the epitheca of *C. petropolitanus*, which is often of sufficient tenuity to allow the bases of the corallites to be seen through it.

Position and locality: Cincinnati group, Cincinnati, Ohio.

CHÆTETES DISCOIDEUS, James.

Plate 21, figs. 15-15c.

Chætetes discoideus, James; Catalogue of the Lower Silurian Fossils of the Cincinnati Group, 1871. (Named, but not figured or described.)

Corallum free, discoid, sharp-edged, concavo-convex, from five to eight lines in diameter, and from one to nearly two lines in greatest thickness. Under surface concave, covered with a very thin epitheca, which but for one or two obscure concentric wrinkles is nearly smooth, and which is in general so delicate as to reveal clearly through its substance the bases of the superjacent corallites. Upper surface gently convex, not exhibiting any tubercles or elevations of any kind. Corallites sub-equal, the larger ones usually scattered irregularly amongst the smaller ones, and rarely aggregated into distinct groups. Calices with moderately thin walls, polygonal or sub-circular, from eight to ten in the space of one line. The ordinary corallites are not separated by any system of minute intermediate tubuli.

I am not sure that *C. discoideus*, James, is distinct from the young of *C. petropolitanus*. It is, however, a common form, and is very constant in its dimensions. Apart from its discoidal, plano-convex shape, it is distinguished by its great comparative thinness, and the resulting shortness of the corallites, the sharp thin edges of the disc, the absence of surface tuberosities and of distinct groups of large-sized corallites, and the fact that the epitheca is not regularly striated in a concentric manner. Still less am I certain that *C. discoideus* can be kept separate from *Chætetes (Nebulipora) lens*, McCoy, of which, however, I have not, unfortunately, had the opportunity of examining an authentic specimen. In the meanwhile, therefore, I have allowed *C. discoideus* to stand, chiefly upon the ground that *C. lens* is stated by McCoy to exhibit conspicuous and definite groups of large sized corallites (four or five corallites in the space of one line), whilst such groups are altogether wanting or very imperfectly developed in the present species.

Position and locality: Cincinnati group, Cincinnati, Ohio. Occurs, also, on the same horizon, at Weston, near Toronto, Canada West.

CHÆTETES FILIASA, D'Orbigny ?

Monticulipora filiasa, D'Orbigny; Prodr. de Paléont., pl. 1, p. 25.

Chætetes filiasa, Edwards and Haime; Pol. Foss. des Terrs. Paléoz., p. 266.

Corallum forming irregular masses, attached by their bases to some foreign object. Surface more or less convex, covered with small rounded

tubercles, which are occupied by corallites of the ordinary size or slightly larger. Corallites thin-walled, polygonal, about eight in the space of one line, without minute interstitial tubuli.

I feel altogether uncertain as to the correctness of this determination, having seen only a single specimen, and that an imperfect one, which I could refer here. The specimen in question forms a mass about three inches and a half in length and nearly an inch and a half thick, growing upon *Ambonychia radiata*, Hall. It appears to me, however, that it is impossible to separate this species satisfactorily from *C. petropolitanus*, unless we are prepared to restrict this latter species entirely to forms which had the base covered with an epitheca, and had a free habit of existence.

Position and locality: Cincinnati group, Cincinnati, Ohio. Collected by Mr. U. P. James.

CHÆTETES MAMMULATUS, D'Orbigny.

Monticulipora mammulata, D'Orbigny; Prodr. de Paléont., 1850.

Chætetes mammulatus, Edwards and Haime, Pol. Foss. des Terr. Paléoz., p. 267, pl. 19, fig 1.

Monticulipora mammulata, Edwards and Haime; Brit. Foss. Corals, p. 265.

Corallum forming irregular expansions of very considerable size, sometimes palmate or lobate, carrying the polypes on both sides. Thickness of the corallum usually varying from two to four lines. Surface covered with well-marked and prominent tuberosities, usually of a rounded or obtusely conical form, the elevation of which varies in different specimens. The tubercles are somewhat irregularly arranged, at intervals of one line to a line and a half apart, and they are covered with calices which are very slightly larger than the average, occasionally with some very minute tubes interspersed amongst them. The corallites are subequal, polygonal, with thin walls, from eight to ten in the space of one line. Very rarely one or two very minute calices may be detected at the angles of the average corallites.

This species represents *C. Dalci* in the ramose series, but is distinguished by its mode of growth and its less prominent tubercles. It is further distinguished by its small thin-walled polygonal corallites, the absence of exceedingly minute interstitial tubuli, and the fact that the tubercles are covered with calices, which in general are rather larger than the average.

With a single well-marked exception, all the examples of this form which have as yet come under my notice are frondescant and lamellar,

and do not, therefore, exhibit the sub-massive mode of growth which is stated to be characteristic of this species.

Position and locality: Cincinnati group, near Cincinnati, Ohio. From the collection of Mr. U. P. James.

CHÆTETES FRONDOSUS, D'Orbigny?

Plate 22, figs. 1, 1b.

Monticulipora frondosa, D'Orbigny; Prodr. de Paléontologie, 1850.

Chætetes frondosus, Edwards and Haime; Pol. Foss. des Terr. Palæoz., pl. 19, fig. 5.

Monticulipora frondosa, Edwards and Halme, Brit. Foss. Corals, p. 265.

Corallum forming erect, flattened, undulating expansions, polypiferous on both sides, of unknown but considerable height, and varying from less than one line to three lines in thickness. Calices sub-circular, from eight to ten in one line, almost or quite half their diameter apart, separated by numerous very small cylindrical tubuli, which render the spaces between the corallites minutely porous. Surface with stellate or sub-circular spaces, which may either not project at all, or may be elevated in the form of low, rounded tubercles, and which are occupied by minute tubuli similar to those which separate the ordinary tubuli. Often the corallites immediately surrounding these spaces are larger than the average, the tubercles being usually arranged in irregular diagonal lines, and placed at distances of about one line apart.

I am not at all satisfied that the specimens from which the above description is drawn are really referable to the form described by D'Orbigny under the name of *Monticulipora frondosa*; but not having at this moment access to this author's description, I provisionally describe our examples under this name. Should they prove to be distinct, the name of *Chætetes Ohioensis* might be applied to them. I am also uncertain whether some of the thinner expansions which I have here described along with the more robust forms, do not constitute part, at any rate, of the *Chætetes (Ptilodictya) pavonia* of D'Orbigny.

This species represents *C. sub-pulchellus*, Nich., in the ramose series, but is distinguished from it not only by its frondescent mode of growth, but also by the much greater development of the system of interstitial tubules which it exhibits, the tubuli in the latter being confined to the tubercular spaces, and not existing between the ordinary corallites.

Many examples of this species appear to have attained a large size, and are now only to be found in a broken condition. Mr. U. P. James, however, has furnished me with a number of nearly perfect specimens,

which have the form of small, flattened fronds, about an inch or an inch and a half in height, and three-quarters of a line in thickness, which would appear to be probably young examples of this form.

Position and locality: Cincinnati group, Cincinnati, Ohio.

CHÆTETES CLATHRATULUS, James.

Plate 22, figs. 2, 2b.

Stictopora clathratula, James; Cat. of the Lower Sil. Foss. of the Cincinnati group, 1871. (Named, but not figured or described.)

Corallum forming a thin, undulating expansion, of unknown but considerable size, and from half a line, or less, to nearly a line and a half in thickness. The frond evidently grew in an erect position, as it consists of two layers of corallites which have their bases fixed to a common calcareous membrane, and open on opposite sides of the corallum. The corallites thus vary from less than a quarter of a line to over half a line in height, and they are slightly oblique to the surface and to the central lamina. The calices are somewhat oblique, the lower lip sometimes very slightly prominent, the walls moderately thick, for the most part altogether equal in size, about ten in the space of one line, arranged in very regular diagonal lines, which are disposed in two sets crossing the corallum from side to side and intersecting at acute angles. Surface, with low, rounded, and obscure elevations, arranged in diagonal rows at intervals of from a line to a line and a half, and occupied by corallites which are either no larger, or but slightly larger, than the average. There is a total and entire absence of minute interstitial tubules between the corallites.

This beautiful fossil at first sight might be taken for one of the explanate *Ptilodictyæ*, though clearly not of this nature. I have not, however, been able to satisfy myself as to its possession of tabulæ, and am thus not altogether certain as to its generic affinities. In the form of the calices, however, and more especially in the presence of low tubercles, it fully resembles *Chætetes*, and I have little doubt as to its being properly placed in this position. It is distinguished from the other frondescient species of *Chætetes* by the arrangement of the calices in regularly intersecting diagonal lines, by the fact that the tubercles are not only very low, but are not occupied by corallites which are conspicuously either larger or smaller than the average, and by the complete absence of small tubes amongst the ordinary corallites.

Position and locality: Cincinnati group, Cincinnati, Ohio. Collected by Mr. U. P. James.

CHÆTETES PAPILLATUS, McCoy.

Nebulipora papillata, McCoy; Ann. and Mag. Nat. Hist., 2d series, Vol. VI., p. 284, 1850; Brit. Pal. Foss., pl. 1c, fig. 5.

Chætetes tuberculatus, Edwards and Haime; Pol. Foss. des Terr. Palæoz., pl. 19, figs. 3, 3a.

Monticulipora papillata, Edwards and Haime; Brit. Foss. Corals, pl. 62, figs. 4, 4a.

Corallum forming an exceedingly thin crust, usually about half a line thick, growing upon Brachiopods and other foreign objects. Surface exhibiting rounded tuberosities, sometimes very slightly elevated, placed about their own diameter apart, occupied by corallites of larger size than the average. Corallites polygonal, thin-walled, somewhat variable in size, but not having any very minute tubuli intercalated amongst them. The average corallites are from eight to ten in the space of one line, those occupying the tubercles being from five to six in one line.

Our specimens agree well with the description given by McCoy of *Nebulipora papillata*, but they differ somewhat from that given by Edwards and Haime. Thus the tubercles in all the examples that I have seen are rounded, not to any extent elongated or markedly compressed, and the larger corallites occupying these eminences are decidedly smaller. The tubercles are not uncommonly perforated by regular and large circular perforations, which appear to be the mouths of vertical tubes, and have a diameter of about half a line. This same phenomenon is very conspicuous in many examples of *C. mammulatus*, *C. petropolitanus*, *C. frondosus*, and other species of *Chætetes*, and in many respects reminds one of the perforations produced by *Cliona*. I am not, however, prepared to assert that this is their true nature.

In its general characters *C. papillatus*, McCoy, approaches *C. mammulatus*, D'Orb.; but it is readily distinguished by its forming very thin crusts, which are attached parasitically to the outside of submarine bodies. It is easily distinguished from *C. corticans*, Nich., by the very long, narrow tubercles which characterize the latter.

Position and locality: Cincinnati group, Cincinnati, Ohio.

CHÆTETES CORTICANS, Nicholson.

Plate 22, figs. 6, 6a.

Corallum parasitic, forming a thin and expanded crust, less than one quarter of a line thick, or when in superposed layers attaining a thickness of half a line. Surface exhibiting a number of long, narrow, com-

pressed tubercles, which are all drawn out in one direction, and which are occupied on their sides by the ordinary corallites, though sometimes more or less compact at their summits. The long diameter of these tubercles varies from two-thirds of a line to two lines, their width not exceeding half a line, and their height being variable (usually equal to the width). They are arranged in tolerably regular diagonal lines, from half a line to two-thirds of a line apart. The corallites are thin-walled, polygonal, sub-equal, from eight to ten in the space of one line, apparently altogether without any intermediate tubuli. There are also no groups of large sized corallites.

This very distinct species is related to *C. papillatus*, McCoy; but is sufficiently separated by the long, narrow tubercles, which do not carry large sized corallites. All the specimens which I have seen are in the form of thin and extended crusts, growing parasitically upon the exterior of *Orthocerata*. In some examples, the tubercles are depressed (probably from attrition), and appear to be nearly solid, but they are more commonly strongly elevated, and carry corallites of the ordinary dimensions on their sides.

Position and locality: Cincinnati group, Cincinnati, Ohio. Collected by Mr. U. P. James.

CHÆTETES ORTONI, Nicholson.

Plate 22, figs. 3, 3b.

Corallum forming exceedingly thin crusts, not more than from one-sixth to one-eighth of a line in thickness, growing parasitically upon foreign objects. Crusts usually forming a circular expansion, half an inch or more in diameter, sometimes irregular and indefinite in outline. Surface exhibiting numerous minute rounded or conical eminences, placed at distances apart of half a line, less or more. Tubercles usually more or less compact at their summits, carrying on their sides corallites which are little or not at all larger than the average. Corallites somewhat oblique to the surface, moderately thick-walled, sub-equal, without any intercalated very minute tubuli. Calices small, sub-polygonal, from ten to twelve in the space of one line, their margins thick and surmounted by very minute and crowded miliary tubercles, which are rounded and not spinous, and are placed almost in contact with one another.

In external appearance, this species, but for its excessive tenuity, and the close-set, pointed and conical tubercles, might be taken as the young

of *C. papillatus*, McCoy; but under a sufficient magnifying power it is readily distinguished by the fine and close tuberculation of the margins of the comparatively minute calices, which gives to the surface an altogether characteristic appearance. All the specimens which I have seen of this singular form are parasitic upon the valves of *Strophomena alternata*, Conrad, and I am informed by Mr. U. P. James that it rarely or never occurs in any other situation. I have named the species in honor of my friend Prof. Edward Orton, from whom I first received specimens.

Position and locality: Cincinnati group, Cincinnati, Ohio.

CHÆTETES NEWBERRYI, Nicholson.

Plate 22, figs. 4, 4a.

Corallum forming a thin, nearly circular or semi-circular expansion, about one-third of a line in thickness, and from ten lines to an inch or more in diameter, and apparently growing parasitically upon submarine objects. Surface almost wholly destitute of elevations and never exhibiting distinct tubercles, but presenting well-marked and conspicuous groups of large sized corallites, which are placed from one line to a line and a half apart, and can hardly be said to be raised at all above the general surface. Calices more or less polygonal or sub-quadrate, with remarkably thin walls, often arranged in tolerably regular diagonal lines, never exhibiting any minute interstitial tubuli. The ordinary calices are about eight in the space of one line, the larger sized ones, occupying the definite groups, about six to one line; and from the thinness of the walls both appear to be unusually large. The margins of the calices are not tuberculated or granulated, and the corallites are perpendicular to the surface.

The distinctness of this species is unquestionable; but I have not been able to satisfy myself that it is attached parasitically to foreign bodies. From the fact that the expansions in some instances have the shape of *Strophomena alternata*, and from the great tenuity of the corallum when broken across, I should conclude that it must certainly be an incrusting species; but I have not yet seen a specimen in which I could demonstrate the existence of any foreign body beneath the crust. If not incrusting, it must have been free, and have been provided with an epitheca below; but this seems very unlikely.

Apart from its mode of growth, *C. Newberryi* may be said to represent *C. pulchellus*, Edw. and H., which it resembles in its smooth surface and

the possession of very well-marked and conspicuous groups of large sized corallites. It differs from this latter species, however, in its never possessing minute interstitial tubuli, so far as I have seen, and in the apparently very large size of the calices produced by the extraordinary thinness of the walls. From such free forms as *C. petropolitanus* and *C. discoideus*, it is distinguished by its extreme thinness as compared with its breadth, as well as by the large size of the corallites.

The above description is drawn from specimens obligingly furnished me by Mr. U. P. James, and I have named the species in honor of Professor Newberry, one of the most distinguished of palæontological observers and writers.

Locality and position: Cincinnati group, Cincinnati, Ohio.

CHÆTETES PETECHIALIS, Nicholson.

Plate 22, figs. 5, 5a.

Corallum incrusting, forming small circular patches, from less than half a line to a line and a half in diameter, attached by their bases parasitically to some foreign body, and more or less strongly convex above. The surface is usually smooth, but not uncommonly exhibits a single central elevation or tubercle. The calices are sub-circular and sub-equal, with moderately thick walls, their margins not tuberculated or granulated, entirely without minute interstitial tubuli, their size very small, from fourteen to sixteen occupying the space of one line. The corallites in the center of the mass are nearly perpendicular, but they become more or less oblique toward the margins.

It is possible that this may be a young form of some other incrusting species, such as *C. papillatus*, McCoy; but I do not think this is the case. At any rate, in the absence of any specimens by which this could be connected directly with any other known form, I have thought it best to place it under a separate title, since it is not only common in its occurrence, but is also very constant in its size and other characters. It is distinguished by its forming very minute, circular, and convex patches, by the absence of interstitial tubules, and by the extremely small size of the calices. All the examples which I have seen are attached parasitically to the exterior of *Strophomena alternata* and different species of *Chætetes*, and in general many colonies are found attached to the same object. I am indebted for the specimens from which the above description is drawn to the kindness of Mr. U. P. James.

Position and locality: Cincinnati group, Cincinnati, Ohio.

GENUS CONSTELLARIA, Dana.

(Zoöph., p. 537, 1846.)

Stellipora, Hall; Pal. N. Y., Vol. I., p. 79, 1847.

Corallum compound, composed of numerous cylindrical corallites, which radiate in all directions from an imaginary central plane or axis, and which are more or less conspicuously separated by very minute intervening tubuli. Septa absent. Tubulæ well developed. No mural pores. Surface exhibiting numerous star-like spaces, which consist of a central, depressed, solid, or minutely tubular area, surrounded by a number of prominent elevated ridges, which are radiately arranged, and carry the ordinary corallites.

No doubt can be entertained as to the propriety of the removal of *Constellaria* from the *Polyzoa*, and its reference to the true corals. It is not, however, altogether certain if the genus can be properly placed in the *Favositidæ*, in the immediate neighborhood of *Chætetes*, as has usually been done. In many respects, *Constellaria* presents a very striking resemblance to the frondescent forms of *Chætetes*, but there would also be good ground for referring the genus to the *Milleporidæ* and placing it near *Fistulipora*, McCoy.

CONSTELLARIA ANTHELOIDEA, Hall.

Stellipora antheloidea, Hall; Pal. N. Y., Vol. I., pl. 26, figs. 10a, 10c.*Stellipora antheloidea*, D'Orbigny; Prod., 1850.*Constellaria antheloidea*, Milne Edwards and Haime; Pol. Foss. des Terr. Palæoz., pl. 20, fig. 7.

Corallum composed of palmate or sub-palmate expanded fronds, or flattened stems, which must have grown in an erect position, attaining a height of two inches or more, and having a thickness of from one and a half to two lines. Surface polypiferous on all sides, the corallites cylindrical, and radiating in all directions from an imaginary central plane or axis. Scattered over the entire surface are numerous conspicuous, more or less prominent stars, each of which has a diameter of one line or a little less, and is composed of a central, sometimes depressed, smooth area, and of generally from six to eight prominently elevated ridges, which radiate from the central space, and occasionally have smaller rays intercalated between them. The stars are usually circular in shape, sometimes elongated or elliptical, and generally arranged in irregular

oblique or transverse rows, two stars usually occupying a space of two lines and a half. The central area of each star is very minutely pitted or porous, being apparently composed of very minute tubuli, but appears to be solid unless examined with a sufficiently high magnifying power. The elevated rays of the stars, and all the comparatively depressed portions of the surface between the stars, are covered with small circular calices, of which ten or twelve occupy the space of one line. The calices are sometimes in contact, but they are more usually separated from one another by half their own width or more. The spaces between the calices appear to be sometimes solid, but they are more commonly minutely tubular, this latter condition almost certainly representing the true structure of the coral. The coralites exhibit no traces of septa, but well developed though delicate tabulæ.

On the one hand, *C. antheloidea* has close affinities with *Chætetes frondosus*, D'Orb., from which it differs in little that is essential, save the peculiar star-like elevations of the surface. On the other hand, as already pointed out, this species approximates closely to *Fistulipora*, and if it could be proved that the minute interstitial tubuli were cœnenchymal, instead of being aborted corallites, then this approximation would be converted into a true generic affinity. In the third place, there is a decided resemblance between this form and such species of *Callopora* as *C. incrassata*, Nich., in which there are star-like spaces occupied by exceedingly minute tubes, but these spaces have no radiating ridges surrounding them.

Position and locality: Cincinnati group, Cincinnati, Ohio.

CONSTELLARIA POLYSTOMELLA, Nicholson.

Plate 22, figs. 7, 7a.

Corallum in all essential points of structure resembling the preceding, consisting of erect, flattened, palmate expansions, the thickness of which is from two to three lines. Surface covered with very prominent stars, formed of a series of elevated ridges radiating from a central depressed area, and surrounded by depressed interspaces. Each star is usually composed of from eight to as many as thirteen elevated ridges, some of which are smaller than the others. The ridge-like elevated rays are occupied by comparatively large sized circular calices, which are also present, though not so closely set, in the interspaces between the stars. The central areas of the stars are occupied by innumerable excessively

minute circular pores, which appear to be the openings of cœnenchymal tubuli, and similar pores exist every where between the corallites which are placed in the intervals between the different stars. Each star is (in the best preserved portions of the coral) circumscribed and separated from the adjacent stars by a distinct hexagonal border, which has no great width, and is occupied solely by the cœnenchymal tubuli, and not by the ordinary corallites.

Though undoubtedly closely allied to *Constellaria antheloidea*, Hall, it seems to me that *C. polystomella* is sufficiently distinguished by the fact that the different stars are definitely bounded in the latter and appear to occupy definite polygonal areas, whilst in the former no line of demarkation can be detected between the different stars other than that afforded by the outer terminations of the elevated ridges. In addition to this character, however, the present species would seem to be distinguished by its very prominent stars, by the large number of rays which are generally present in each individual star, and by the conspicuous presence, both in the central areas of the stars and also in the interspaces between the different corallites elsewhere, of very numerous and very minute cylindrical tubuli, which can hardly be regarded as other than cœnenchymal.

The only example of this species that I have seen was collected by Mr. U. P. James, of Cincinnati.

Position and locality: Rare in the Cincinnati group, Cincinnati, Ohio.

GENUS AULOPORA, Goldfuss, 1826.

(Petref. Germ., p. 32.)

AULOPORA ARACHNOIDEA, Hall.

Plate 23, figs. 1, 1b.

Aulopora arachnoidea, Hall; Pal. N. Y., Vol. I., p. 76, pl. 26, figs. 6a, 6c.

Corallum very slender and delicate, attached to the surface of foreign bodies, repeatedly branching, and, in many examples, anastomosing to form a close net-work. The branches are usually given off at intervals of from one-third to two-thirds of a line, and are linear and very narrow. The corallites have much the characters of the uniserial forms of *Alecto*, being arranged in single lines, and opening in the axis of the branches. The terminal portion of the corallite is elevated above the general surface, and the calices are circular and not expanded. About four or five calices occupy the space of one line.

Some examples of this species are branched with tolerable regularity, as in the specimen figured; but others form very confused and closely interlaced reticulations. No positive or absolutely definite characters can be stated which would lead to the reference of this fossil to *Aulopora* rather than to *Alecto*. Nevertheless, the general aspect of the fossil is such that it can almost positively be placed in the former genus. The forms to which it presents the nearest resemblance are *A. filiformis*, Billings, and *A. (?) Canadensis*, Nich., both of which are Devonian; but it is readily distinguished from these, and by no character more conspicuously than by the fact that the corallites open in the axis of the branches, instead of forming an angle with the main stem. With a little care, there is also no great difficulty in separating it from *Alecto auloporoïdes*, Nich., to which it bears a considerable superficial resemblance.

The examples of *Aulopora arachnoidea* described by Hall are from the Trenton limestone, but our examples are from the horizon of the Hudson River group. The specimens which I have seen are attached to the exterior of different ramose species of *Chætetes*.

Position and locality: Cincinnati group, Cincinnati, Ohio. From the collections of Mr. U. P. James and Prof. Edward Orton.

GENUS STREPTELASMA, Hall, 1847.

(Pal. N. Y., Vol. I., p. 17.)

Corallum simple, turbinate, free; epitheca well developed; septa well developed, more or less twisted and united with one another towards the center of the visceral chamber, where they sometimes form a species of vesicular tissue. No columella, nor any dissepiments. Tabulæ remote, irregular, and poorly developed. A single septal fossette.

This genus stands in a somewhat dubious position; but I see at present no option but to retain it, if *S. corniculum* is to be taken as the type of the genus. The badly characterized genus *Petraia*, Munst., is stated to possess no tabulæ; otherwise *Streptelasma* would certainly have to be regarded as a synonym of this, as has already been done by McCoy and Billings. On the other hand, Milne Edwards and Haime (Brit. Foss. Corals, Introduction, p. 68) state that *Streptelasma* is separated from *Cyathophyllum* by the fact that the wall is "destitute of an epitheca and covered by sub-lamellar costæ." This I do not comprehend, as the many specimens of *S. corniculum* which have come under my notice have the epitheca remarkably well developed, except when they have been much

weathered. Lastly, from *Cyathophyllum* proper *Streptelasma* is distinguished chiefly, or solely, by the total absence of dissepiments and the comparatively rudimentary condition of the tabulæ.

STREPTELASMA CORNICULUM, Hall.

Streptelasma corniculum, Hall ; Pal. N. Y., Vol. I., pl. 25, figs. 1a, 1e.

Streptelasma crassa, Ibid. ; pl. 25, figs. 2a, 2e.

Streptelasma multilamellosa, Ibid. ; pl. 25, figs. 3a, 3c.

Streptelasma parvula, Ibid. ; pl. 25, figs. 4, 4c.

Streptelasma corniculum, Edwards and Haime ; Pol. Foss. des Terr. Palæoz., pl. 7, fig. 4.

Corallum conical, slightly curved, or nearly straight, averaging from one to four inches in length, and from ten lines to an inch and a half in diameter. Septa numerous, from ninety to one hundred and sixty in number, alternately large and small. The small septa rarely extend much beyond the margin; but the large ones extend to the center, in approaching which they become more or less twisted, and unite with one another, sometimes giving rise to a central mass of vesicular tissue. Calice moderately deep. Septa very thick, and often appearing as if composed of two lamellæ. Tabulæ remote and irregular, sometimes elevated towards the center of the visceral chamber. No dissepiments. A single septal fossette, usually placed on the curved side of the coral. Epitheca exhibiting longitudinal ridges corresponding with the septa within; otherwise smooth, or, rarely, with a few encircling shallow folds of growth.

This species—if all the specimens I have referred to it rightly belong to it—is very variable in size, in the amount of curvature, and in the number of septa. The following are the dimensions of a number of apparently typical examples:

1. Four inches long; diameter at summit nearly an inch and a half; one hundred and sixty septa, alternately large and small. This is the largest specimen I have seen, but imperfect at its summit.

2. Length over three inches; diameter at summit fourteen lines; one hundred and twenty-six septa, alternately large and small.

3. Length one and a half inch; diameter at summit fourteen lines; one hundred and twenty-six septa, alternately large and small. A broken specimen.

4. Length one inch and a half; diameter at summit ten lines; one hundred and fourteen septa, alternately large and small.

5. Length one inch; diameter at summit nine lines; ninety-six septa, alternately large and small.

6. Length fourteen lines; diameter at summit nine lines; ninety septa, alternately large and small.

7. Length six lines; diameter at summit four and a half lines; septa thirty, all equal in size and extending to the center. This would appear to the form described by Hall under the name of *S. parvula*, and I do not feel sure whether it is the young of *S. corniculum* or really a distinct species.

The average number of septa in a typical example of *S. corniculum* would appear to be one hundred and twenty, or thereabouts. Hall gives the number at sixty, but in this enumeration he appears to have neglected the smaller secondary septa. Prof. Hall, however, gives one hundred and twenty as the number of the septa in his *S. multilamellosa*, which would seem to be probably only a variety of *S. corniculum*.

Position and locality: Upper beds of Cincinnati group, Waynesville, Lebanon, Oxford, etc., Ohio.

GENUS PALÆOPHYLLUM, Billings, 1857.

(Geol. Survey of Canada, Report of Progress, 1857, p. 168.)

“Corallum fasciculate or aggregate; corallites surrounded by a thick wall; radiating septa extending the whole length; transverse diaphragms either none or rudimentary; increase by lateral budding. This genus only differs from *Petraia* or *Streptelasma* by forming long fasciculate or aggregate masses, instead of being simple.” (Billings, *loc. cit.*)

Amongst the numerous specimens from the Cincinnati group kindly submitted to me by Mr. U. P. James are several which agree with *Streptelasma corniculum*, Hall, in most respects, but differ in the fact that they produce lateral buds, or sometimes appear to divide fissiparously. They do not form large colonies, but usually consist of from two to six or seven corallites. They do not thus constitute “fasciculate or aggregate masses”; but I have thought it advisable to refer them provisionally to this genus, rather than to form a new genus for their reception upon insufficient material.

PALÆOPHYLLUM DIVARICANS, Nicholson.

Plate 22, figs. 10, 10b.

Corallum usually free, sometimes apparently attached, compound, formed of conical, turbinate corallites, which are produced by lateral gemmation, or rarely by fission, and which are directed outwards from the parent, usually at a more or less open angle, and are never in actual contact with one another. The number of corallites in the corallum, so far as observed, varies from two to six. Septa from fifty-eight to sixty-two, alternately large and small, the large ones becoming twisted as they approach the center of the visceral chamber, where they unite with one another laterally, and form a more or less developed central mass of vesicular tissue. No dissepiments nor columella. Tabulæ unknown. Wall with a well developed epitheca, with longitudinal ridges corresponding with the septa within, and also with faint encircling striæ and a few shallow annulations of growth. Calice deep, with a flattened space at the bottom. Free edges of the septa not furnished with spines or denticulations. Apparently no fossette.

The best preserved specimen which has come under my notice consists of two corallites, one budded from the side of the other nearly at right angles. The largest corallite has a length of nearly ten lines, a diameter of calice of seven lines, and a depth of calice of four lines. Another specimen consists of six nearly equally sized corallites, apparently produced by parietal gemmation, and having a length of five or six lines, and a diameter at the calice of about five lines. Another specimen consists of two large corallites which appear to have been produced by fission, being attached only by their pointed bases, and being nearly in contact with one another. The length of the largest of these corallites is more than an inch and a half, and its diameter at the calice is ten lines. Another specimen, precisely similar in its mode of growth, is attached to the dorsal valve of *Rhynchonella dentata*, Hall, the length of the largest corallite being only three lines, and the diameter of the calice the same.

The specimens from which the above description was taken in most respects closely resemble *Streptelasma corniculum*, Hall, especially as concerns their twisted septa; but they possess a much smaller number of septa (if specimens of the same size be compared), and they are always rendered composite by the production of lateral buds or by cleavage.

With *Palæophyllum rugosum*, Billings, the present species can not be

confounded for a moment, the former constituting large masses of scarcely separate corallites, which vary from one to six lines in diameter.

Position and locality: Cincinnati group, Cincinnati, Ohio. Collection of Mr. U. P. James.

GENUS PROTAREA, Edwards and Haime.

(Compt. Rend., T. XXIX., 1849.)

Protarea vetusta, Edwards and Haime.

Porites? vetusta, Hall; Pal. N. Y., Vol. I., p. 71, pl. 25, figs. 5a, 5b, 1847.

Astracopora vetusta, D'Orbigny; Prodr. de Paléont., 1850.

Protarea vetusta, Edwards and Haime; Pol. Foss. des Terr. Paléoz., pl. 14, fig. 6.

Corallum forming thin crusts, about one-third of a line in thickness, which grow parasitically upon foreign bodies. Calices nearly equally developed, usually hexagonal, about one line in diameter or rather less, shallow, the bottom of the cup being tuberculated. Septa twelve in number, sub-equal, extending but a short distance inwards towards the center of the visceral chamber. Walls of the calices thick.

This pretty little coral forms thin crusts upon species of *Strophomena*, *Pleurotomaria*, and other fossils, and there appears to be no reason to doubt its identity with the specimens described by Hall from the Trenton limestone. The form described from the Silurian rocks of Ohio, by Milne Edwards and Haime, under the name of *Protarea Verneuilli*, is chiefly distinguished from this by the slightly larger sizes of the calices, but I have seen no specimens that I could refer to it.

Position and locality: Cincinnati group, near Cincinnati, Ohio.

GENUS TETRADIUM, Dana, 1846.

(Zoöph., Vol. VIII., p. 701.)

"Coralla massive, consisting of four-sided tubes and cells, with very thin septa or parietes; cells stellate, with four narrow laminae."

"This genus is near *Receptaculites*, but differs in having very thin parietes and four distinct rays between the cells, one to each side. The specimen answering to the description is a fossil of uncertain locality in the collections of Yale College, New Haven. The cells are about half a line in breadth." (Dana, *loc. cit.*)

To this definition Prof. J. M. Safford (Amer. Journ. Sci. and Arts, 2d

series, Vol. XXII., p. 236) adds the following: "The tubes in the different species vary from one quarter of a line to nearly one line in breadth; they are very long, and are most frequently united throughout laterally, forming massive coralla resembling more or less those of *Favosites* and *Chætetes*; sometimes, however, they are united in single intersecting series, as in *Halysites catenulata*, Linn.; not unfrequently, too, the tubes are isolated, or only united at irregular intervals, thus forming loose fasciculated coralla resembling certain forms of *Syringopora*."

Prof. Safford further states that the *isolated* tubes are nearly quadrangular, with more or less rounded angles, and with a slight external longitudinal depression opposite to each of the four septa. The walls are more or less rugose, and increase is by fission of the old tubes. Only one specimen was seen in which the tabulæ could be detected, and in this they were confined to one end of the mass, and were distant from one another about twice the width of the tubes.

The genus is regarded by Safford as intermediate between the *Favositidæ* and the *Rugosa*, the quadripartite character of the corallites placing it in the latter group.

The material in my hands at present is insufficient for any further elucidation of this singular genus, and I have nothing to add to the characters above recorded, except that in most of the specimens I have seen the tabulæ appear to be present throughout the whole mass, and can be made out without any difficulty.

Of the four species enumerated by Safford from the Lower Silurian deposits, the Cincinnati group has yielded one form which I believe to be *Tetradium minus*.

TETRADIIUM MINUS, Safford.

Tetradium minus, Safford; Amer. Jour. Sci. and Arts, 2d series, Vol. XXII., p. 238.

Corallum massive, hemispherical, or amorphous, composed of slender closely approximated corallites, which diverge from an imaginary axis. The corallites are of great length, sometimes exceeding three inches, with a width of from one-third to one-fourth of a line, their walls tolerably thick, and their shape irregularly four-sided or five-sided. The septa are apparently four in each corallite, but they are imperfectly preserved, and can only be detected occasionally. There are, however, well developed tabulæ, which are complete and remote, from five to six usually occupying the space of one line.

I do not know if the specimens from which I have taken the above

description are really distinct from *T. fibratum*, Safford, or not; but I have thought it best to keep them separate in the meanwhile, since they agree with *T. minus*, and differ from the former species in the small size of the corallites, of which three or four occupy the space of one line. Our specimens also differ from *T. fibratum* in the greater closeness of the tabulæ, these structures being constantly present, and being very conspicuous. On the other hand, the peculiar septa of the genus are only occasionally recognizable in polished transverse sections.

Position and locality: Upper beds of Cincinnati group, Lebanon, Waynesville, etc., Ohio. From the collections of Prof. Edward Orton and Mr. U. P. James.

CORALS OF THE CLINTON FORMATION.

GENUS FAVOSITES, Lamarck, 1816.

(Hist. des. An. sans Vert., Vol. II., p. 204.)

FAVOSITES GOTHLANDICA, Lamarck.

Favosites Gothlandica, Lamarck; Hist. des An. sans Vert., Vol. II., p. 206.*Favosites Gothlandica*, DeFrance; Dict. Sc. Nat., Vol. XVI., p. 298.*Favosites Gothlandica*, Lamouroux; Encyl. (Zoöph.), p. 338.*Calamopora Gothlandica*, Goldfuss; Petref. Germ., Vol. I., p. 78, pl. 26, figs. 3a, 3b, 3c, 3c, and 3d.*Favosites Gothlandicus*, Eichwald; Zoöl. Spec., Vol. I., p. 194.*Favosites reticulum*?, Ibid.; p. 194, pl. 11, fig. 14.*Calamopora Gothlandica* (pars), Mowen; Descr. Cor. in Belg. Report, p. 72.*Calamopora Gothlandica*, Stephen Kutorga; Beitr. zur Geogr. and Paléont. Dorpat's, p. 24, pl. 5, fig. 2.*Calamopora basaltica*, Hisinger; Leth. Succ., p. 96, pl. 27, fig. 5.*Calamopora Gothlandica*, Eichwald; Sil. Syst. in Esthland, p. 198.*Favosites sub-basaltica*, D'Orbigny; Prodr. de Paléont., Vol. I., p. 49.*Favosites Gothlandica*, McCoy; Pal. Foss., p. 20.*Favosites Gothlandica*, Milne Edwards and Jules Haime; Pol. Foss. des Terr. Palæoz., p. 232.*Favosites Niagarensis*, Hall; Pal. N. Y., Vol. II., p. 125, pl. 34, A (bis), fig. 4, and p. 324, pl. 73, fig. 1.*Favosites Goldfussi*, D'Orbigny; Prodr. de Paléont., Vol. I., p. 107.*Favosites Goldfussi*, Milne Edwards and J. Haime; Pol. Foss. des Terr. Palæoz., pl. 20, fig. 3.*Favosites Goldfussi*, Edwards and Haime; British Foss. Corals, pl. 47, figs. 3, 3c.*Favosites Gothlandica*, Billings; Canadian Journ., 2d Ser., Vol. IV., p. 99.*Favosites Gothlandica*, Nicholson; Can. Journ., 2d Ser., Vol. XIV., No. 1, p. 41.*Favosites Gothlandica*, Nicholson and Hinde; Can. Jour., 2d Ser., Vol. XIV., No. 2, 1874.*Favosites Gothlandica*, Nicholson; Report on the Palæontology of Ontario, p. 45, 1874.

(The above includes only the more important synonyms of this widely distributed and variable species.)

Corallum massive, forming spheroidal, pyriform, or more or less hemispheric masses, which often attain a very large size. Corallites in general markedly polygonal, and for the most part tolerably uniform in their

dimensions, varying in different examples from one to two lines in diameter, though usually rather over one line. Mural pores usually in two rows on each of the prismatic faces of the corallites, arranged alternately, or sometimes oppositely, and surrounded by elevated margins. Tabulæ usually complete, extending across the visceral chamber without interruption. Septa usually altogether absent, or at most represented by tubercles or short spines.

The limits of this variable species can perhaps at present be hardly laid down with certainty, but we may safely include under this head those massive forms of *Favosites* in which the corallites are prismatic, thin-walled, approximately equal in size, about one line, or rather more, in diameter, with two rows of mural pores on each of the prismatic faces of the corallites, these openings being usually arranged alternately. Except in well-preserved specimens, however, it must be admitted that it is by no means always easy to determine examples of *F. Gothlandica*.

Position and locality: Clinton group, Greene county, Ohio.

FAVOSITES ASPERA, D'Orbigny.

Calamopora alveolaris (pars), Goldfuss; Petref. Germ., Vol. I., pl. 26, fig. 1b. (Cæt. exclusis.)

Favosites alveolaris, Lonsdale; Sil. Syst., p. 681, pl. 15 bis, fig. 2.

Calamopora alveolaris, Eichwald; Sil. Syst. in Esthland, p. 198.

Favosites alveolaris, Lonsdale; In Murch. Vern. and Keys. Russia and Ural, Vol. I., p. 610.

Calamopora alveolaris, Keyserling; Reise in Petschora, p. 177.

Favosites aspera, D'Orbigny; Prodr. de Paléont., Vol. I., p. 49.

Favosites aspera (?), McCoy; Pal. Foss., p. 20.

Favosites aspera, Edwards and Haime; Pol. Foss. des Terr. Palæoz., p. 234.

Favosites aspera, Edwards and Haime; Brit. Foss. Corals, pl. 60, figs. 3, 3a.

Corallum massive, sub-hemispheric or pyriform; corallites polygonal, thin-walled, unequal in their dimensions, the larger ones about one line in diameter or a little over. Mural pores placed on the angles of the corallites, instead of on their flat faces. Tabulæ with six large and well marked sub-marginal fossulæ.

A small mass from the Clinton formation of Ohio may be referred here, though its state of preservation is such that the characters of the tabulæ can not be determined. It can not, therefore, be made out with accuracy whether the specimen in question is really *F. aspera* or the very closely allied, if not identical, *F. alveolaris*, Gold. From the inequality

in the size of the calices, it may, however, be referred with tolerable certainty to the former species. I am not aware that this form has previously been detected in the North American continent.

Position and locality: Clinton group, Clarke county, Ohio.

FAVOSITES VENUSTA, Hall.

Astrocerium venustum, Hall; Pal. N. Y., Vol. II., pl. 34, figs. 1a, 1i.

Favosites venusta, Nicholson and Hinde; Canadian Journ., 2d series, Vol. XIV., No. II., 1874.

Corallum forming large hemispherical or spheroidal masses, which are usually composed of a succession of concentric layers, and generally have a more or less flattened upper surface. Corallites slender, variable in size, polygonal, rapidly increasing in number by fission, so that the mass increases rapidly in size in proceeding from the base upwards. The larger corallites are usually about half a line across, but they have many smaller ones intercalated amongst them, the diameter of which varies from the fiftieth of an inch up to half a line. The calices are hexagonal, polygonal, or sub-cylindrical, and there are usually rudimentary septa in the form of very short spiniform projections. The tabulæ are complete, straight or flexuous, from four to six occupying the space of one line. Mural pores undeterminable.

The genus *Astrocerium* was found by Hall (Pal. N. Y., Vol. II., p. 126) to include corals precisely similar in most respects to the typical species of *Favosites*, except that they possess spiniform septa. Septa, however, are by no means wanting, even in the most characteristic species of *Favosites*, as, at any rate, an occasional thing. If it could be shown, as Hall seems to have believed, that the corals which he referred to *Astrocerium* are destitute of mural pores, then the genus might perhaps be retained; but in the meanwhile this has not been proved, and it is, therefore, impossible to separate *Astrocerium* from *Favosites*.

The present species can readily be distinguished from *F. Gothlandica*, Lam., by the small size of the corallites, and the great inequality in their dimensions. It most nearly resembles *F. hemispherica*, Yand. and Shumard, of the Devonian series, but it is separated from it without difficulty by its totally different mode of growth, and by the fact that the tabulæ are both more remote and complete. The species appears to have commenced its existence in the Clinton formation, but it attains its highest development in the Niagara period.

Position and locality: Clinton group, Yellow Springs, Ohio.

HALYSITES CATENULARIA, Linnæus.

Tubipora catenularia, Linné; Syst. Nat. Ed. XII., p. 1270, 1767.

Catenipora labyrinthica, Goldfuss; Petref. Germ., Vol. I., p. 75, pl. 25, fig. 5.

Catenipora escharoides, DeBlainville; Man., pl. 65, fig. 5.

Catenipora escharoides, Hall; Pal. N. Y., Vol. II., pp. 44 and 127, pl. 18, fig. 2, and pl. 35, fig. 1.

Halysites catenularia, Edwards and Haime; Pol. Foss. des Terr. Palæoz., p. 281.

Halysites catenularia, Edwards and Haime; Brit. Foss. Corals, pl. 64, figs. 1, 1c.

It does not seem necessary to give either a description or a full synonymy of this very common and well known coral. It is most readily recognized by the loosely reticulated corallum, composed of interlacing vertical plates, each of which in turn is made up of tabular corallites. The tabulæ are well developed, and the existence of septa can often be determined without difficulty. The size of the meshes of the corallum varies very much, though not so much as the size of the individual corallites. The calices are elliptical in shape, and their long diameter may vary from as little as one-third of a line to as much as one line and three-quarters, or more than five times as great. Nevertheless, the gradations between the smallest and largest forms are so numerous that it is impossible to believe that we are dealing with more than a single species. Milne Edwards and Haime, with more or less doubt, retain the name of *Halysites escharoides* for those forms in which the reticulations of the corallum are small, polygonal, and of nearly equal dimensions. I think it very doubtful if this form can be regarded as more than a mere variety of *H. catenularia*; but it appears to me, from the specimens which I have examined, that *H. agglomerata*, Hall, may fairly be considered as distinct.

Position and locality: Clinton group, Preble county, Ohio.

ACERVULARIA CLINTONENSIS, Nicholson.

Plate 23, figs. 2, 2a.

Corallum astræiform, plane composed of polygonal corallites closely united with one another. The outer walls of the corallites very thick, either slightly undulated or straight. The corallites are somewhat unequal in size, and usually pentagonal in shape, their great diagonal varying from three to six lines, but averaging about four lines. The inner wall is extremely well marked, sometimes slightly elevated above the bottom of

the main calice. The true calice varies from two to three lines in diameter. As seen in the inner cup, or true calice, there are from forty to forty-six slender septa, alternately large and small, united with one another laterally by transverse dissepiments. In the space between the two walls the septa are often imperfectly developed, or are so united with one another and broken up by dissepiments as to give rise to a loose and open vesicular tissue.

This form is readily distinguished from all the other species of *Acervularia* with which I am acquainted by the strong and well-marked outer and inner walls, the great development of the septa within the inner cup, the general proportions of the corallites, and the number and inequality in size of the septa.

Position and locality: Clinton group, Yellow Springs, Ohio.

ERIDOPHYLLUM SIMCOENSE, Billings.

Eridophyllum Simcoense, Billings; Canadian Journ., new ser., Vol. IV., p. 132, 1859.

Eridophyllum Simcoense, Nicholson; Report on the Palæontology of Ontario, p. 34, 1874.

Corallum forming colonies of cylindrical, straight, flexuous or crooked corallites, from two to three lines in diameter, distant from one another from one to three lines, and united by short, horizontal connecting processes. The connecting processes are thick at their points of junction with the corallites, and thin in the middle, and they are often, though not universally, turned in the same direction in the same colony. Their distance apart varies from two to six lines. The epitheca usually exhibits encircling annulations of growth, along with vertical ridges corresponding with the septa. There is a well-developed central tabulate area, into which the septa either do not penetrate at all, or extend but a short distance. The septa are between forty and fifty in number, and are alternately large and small.

It is possible that this species may turn out, on a more extensive examination of specimens, to be identical with *E. rugosum*, Edw. and H., from the Upper Silurian of the island of Gothland.

Position and locality: Clinton group, Yellow Springs, Ohio.

CORALS FROM THE NIAGARA FORMATION.

GENUS FAVOSITES, Lamarck, 1816.

(Hist. des An. sans Vert., Vol. II., p. 204.)

FAVOSITES FAVOSA, Goldfuss.

Calamopora favosa, Goldfuss; Petref. Germ., pl. 24, figs. 2a, 2c.*Favosites favosa* (?), Hall; Pal. N. Y., Vol. II., pl. 34 A, figs. 5a, 5c.*Favosites favosa*, Nicholson and Hinde; Can. Journ., 2d ser., Vol. XIV., No. 2, 1874.

Corallum massive, spheroidal, pyriform, or hemispheric, composed of prismatic corallites, the diameter of which, in normal specimens, varies from one to two lines in diameter. The tabulæ are about six in the space of two lines, usually more or less conspicuously curved, with their convexities directed upwards. Mural pores in two alternating rows upon the flat faces of the corallites. Septa absent, or represented by spiniform projections.

The corallum in *F. favosa*, Goldfuss, is essentially similar to *F. Gothlandica*, Lam., and is to be distinguished solely by the slightly larger size of the corallites in ordinary examples, and by the curvature of the tabulæ. I have seen unmistakable specimens of this form from the Niagara limestone of Owen Sound, in Canada, and am inclined to refer here a small mass from the same horizon in Ohio. In this example the corallites vary from a line and a half to two lines in diameter, with a few smaller ones intercalated amongst them, and their shape is usually pentagonal. The tabulæ, however, are straight and not curved. This latter fact renders the reference to *F. favosa* somewhat doubtful, and the same may be said of the specimens described by Hall from the Niagara limestone of Milwaukee (*loc. cit.*, p. 126).

Position and locality: Niagara formation, Dayton, Ohio.

CORALS OF THE CORNIFEROUS LIMESTONE.

GENUS FAVOSITES, Lamarek, 1815.

(Hist. des An. sans Vert., Vol. II., p. 204.)

FAVOSITES TURBINATA, Billings.

Favosites turbinata, Billings; Canadian Journal, new ser., Vol. IV., p. 109, and Vol. V., p. 258, fig. 7.

Favosites turbinata, Nicholson; Canadian Journal, new ser., Vol. XIV., No. 1, p. 48.

Favosites turbinata, Nicholson; Report on the Palæontology of Ontario, pl. 8, figs. 1, 2.

Corallum massive, usually turbinate, with a more or less spirally twisted base, sometimes straight and cylindrical, or at other times more or less irregular in shape. Corallites nearly equally sized, prismatic or sub-prismatic, from half a line to one line in width. Tabulæ flat or flexuous, usually complete. Mural pores of large size, disposed in a single row upon each of the flat surfaces of the corallites. The entire surface is occupied by the calices, but only those in the upper portion of the coral remain open, the remainder being completely closed by a thicker or thinner epitheca.

The specimens of this remarkable species differ much both in shape and in size, being usually more or less in the form of an inverted cone, and varying from less than an inch to two feet in length. The upper portion of the colony is usually thick and broad, sometimes cup-shaped, and here the calices are open. Owing, however, to the fact that the corallites radiate in all directions from an imaginary central line, the entire surface is really occupied by the calices; but those which are placed on all parts of the surface beneath the summit of the mass have their mouths completely sealed up by the development of an epitheca. As a general rule, the epitheca is thin and delicate, and allows the old calices beneath to be distinctly seen; but at other times it may be thick enough to almost conceal from view the calices.

The form and mode of growth of *F. turbinata* sufficiently distinguish it from all other recorded forms. The species, however, is further distinguished by the small size of the corallites, their thick walls, their nearly

uniform dimensions, and their possession of a single row of large mural pores on each of the flat faces.

I have seen fine specimens of this species from the Corniferous limestone of Ohio, and it is one of the commonest and most characteristic fossils of the same formation in Canada. It also occurs, though not so abundantly, in strata of the age of the Hamilton group, in western Ontario.

Position and locality: Corniferous limestone, Kelley's Island, Ohio.

FAVOSITES POLYMORPHA, Goldfuss.

Calamopora polymorpha, Goldfuss; Petref., pl. 27, figs. 2b, 2c, 2d, 3b, and 3c. (Cæt. exclusis.)

Corallum more or less lobate or sub-dendroid, varying in shape and size. Calices more or less polygonal, sometimes becoming round by the thickening of the walls of the corallites, of unequal sizes, a few small ones being intercalated amongst the larger. The diameter of the larger calices is generally from half a line to two-thirds of a line.

It seems questionable whether the strictly dendroid forms of *Favosites*, usually described under the names of *F. reticulata*, DeBlain., and *F. dubia*, DeBlain., can be separated from *F. polymorpha* proper, but I have omitted any allusion to their characters in the above definition. It seems also doubtful if *F. cervicornis*, DeBlain., and *F. cristata*, Edw. and H., can be kept apart from this form.

Position and locality: Corniferous limestone, Antwerp, Ohio.

FAVOSITES PLEURODICTYOIDES, Nicholson.

Plate 23, figs. 3, 3b.

Corallum circular, depressed, apparently discoid, the under surface being flat or slightly concave. The lowermost corallites are parallel with the lower surface, and radiate from the central point like the spokes of the wheel. The corallites are prismatic or sub-cylindrical in shape, about one line in width near the base, but often rapidly widening as they approach the circumference of the colony, their walls pierced with two very distinct rows of alternating mural pores, resembling those of *F. Gothlandica*. Epitheca thin, continuous, but deeply grooved along the lines of junction of the different corallites, concentrically striated, and also exhibiting faint longitudinal striæ. Upper surface and calices unknown.

Of the two specimens examined, one had a diameter of nearly an inch and a half, and the other of ten lines. Both were imbedded in the rock in such a manner as to expose nothing but the flat, discoid, lower surface.

In many respects this form reminds one of *Pleurodictyum problematicum*, Goldfuss; but as the affinities of the latter are not altogether certain, and as our specimens undoubtedly belong to *Favosites*, I have thought it best to consider them as distinct. Even if it were accepted as quite certain that *Pleurodictyum problematicum* is founded upon casts of a species of *Favosites*, I should still be disposed to consider the present form as distinct, since its epitheca differs markedly from that of the former in exhibiting grooves which indicate in the plainest manner, the limits of the superjacent corallites. From the recorded species of *Favosites*, *F. pleurodictyoides* is sufficiently distinguished by its peculiar form and mode of growth. The walls of the corallites are usually well preserved, and are not amalgamated with one another, whilst they support two rows of alternating mural pores.

Position and locality: Corniferous limestone, Kelley's Island, Ohio. From the collection of Prof. Edward Orton.

FAVOSITES INVAGINATA, Nicholson.

Plate 23, figs. 7, 7a.

Corallum massive, conical, or inversely turbinate, composed of a number of funnel-shaped layers invaginated one within the other, or rather of a number of conical layers which are successively superimposed one upon the other. Apex of the mass obtusely pointed, base deeply concave. Corallites short, radiating in each successive layer in all directions from the imaginary center of the colony, polygonal or sub-cylindrical in shape, mostly sub-equal, from one-half to two-thirds of a line in diameter, rarely one line. Septa very distinct, extending nearly to the center of the visceral chamber. Tabulæ very closely set, and apparently usually incomplete. Mural pores large, round, surrounded by an elevated border, in two rows on each face of the corallites, those of each row separated from those of the other by an elevated longitudinal line, and either alternating or opposite to one another.

I have only seen one large specimen of this singular species, which, though imperfect, has a length of four and a half inches, and a diameter of about four inches at its broader end. The specimen is completely silicified, and its state of preservation is such as to prevent the determination of several points of interest. The entire mass is conical, and is composed of successive layers of corallites, which usually have a thick-

ness of about two lines, less or more. At first sight one would imagine that the mass had been fixed by its smaller end, the broader extremity being concave, and apparently having had the corallites opening on this surface. On the contrary, however, a close examination has satisfied me that the reverse of this is really the case. The coral must in reality have been free, and the broad concave end must have been covered with an epitheca which has now disappeared. The calices, therefore, must have opened over the entire convex surface of the cone. That this is the real state of the case is shown, amongst other proofs, by the fact that the entire pointed end of the cone is uninterruptedly covered by the calices, rendering it impossible that the mass can have been attached at this point.

The species to which, at first sight, *F. invaginata* bears the closest resemblance is *F. turbinata*, Billings, but this resemblance ceases the moment the former is held in its proper position. The latter species, also, is fixed by its pointed base, and has its convex sides covered with an epitheca, whilst the corallites are destitute of septa, and the mural pores are uniserial. The present species, on the other hand, had its pointed end directed upwards, and possessed well-developed septa and biserial mural pores. The septa of the corallites are apparently from six to twelve in number, but owing to the silicification of the mass they can not be counted with accuracy. The tabulæ, also, are only shown over a portion of the mass, but they appear to have the characters of *Favosites* (*Emmonsia*) *hemispherica*, being numerous, close-set, and incomplete, and often interlocking by their free ends. From the ordinary forms of *Favosites* the present species is sufficiently separated by its peculiar form and mode of growth, and its well-developed septal system.

Position and locality: Corniferous limestone, Marblehead, Ohio.

GENUS CYSTIPHYLLUM, Lonsdale, 1839.

(Silurian System, p. 691.)

CYSTIPHYLLUM VESICULOSUM, Goldfuss.

Cyathophyllum vesiculosum, Goldfuss; Petref., p. 58, pl. 17, fig. 5, and pl. 18, fig. 1.

Cystiphyllum vesiculosum, Phillips; Pal. Foss., p. 10, pl. 4, fig. 12.

Cystiphyllum vesiculosum, Milne Edwards and Haime; Pol. Foss. des Terr. Pal., p. 462.

Cystiphyllum vesiculosum, McCoy; Brit. Pal. Foss., p. 71.

Cystiphyllum vesiculosum, Nicholson; Rept. on the Palæontology of Ontario, p. 37, fig. 8.

Corallum simple, elongated, turbinate, or cylindro-conic, sometimes almost cylindrical. Epitheca thick, with encircling striæ and folds of growth, the latter being sometimes rounded, sometimes sharp-edged and

imbricating. Calice deep, its bottom usually occupied by a group of bullæ, with very distinct septal striæ, which usually appear to be made up of a succession of elongated vesicles. The internal structure is vesicular, the largest vesicles being central, and having a diameter of from a line to a line and a half.

Young examples of *C. vesiculosum* are strictly simple, but older examples increase in size by a peculiar form of calicular gemmation. In this mode of growth the coral attains a certain size, and then the calice becomes more or less covered up by the extension over it of the epitheca. A fresh corallite is then produced from the primitive oral disc by gemmation, either directly in the axis of the old cup or commonly from one side. After this has lived for a certain time, a third corallite is produced in a similar manner, and the process may be continued until an aged specimen may come to consist of six or eight cups arranged in a vertical series, and each springing from some part of the calice of its predecessor.

An individual of *C. vesiculosum* of average size has a length of three inches, a diameter of the calice of an inch and a quarter, and a depth of the calice of about the same.

Position and locality: Corniferous limestone, Columbus, Ohio. Collected by Mr. J. H. Klippart.

CYSTIPHYLLUM OHIOENSE, Nicholson.

Plate 23, figs. 4, 4a.

Corallum small, turbinate, straight, or slightly curved, from six to nine lines in height. Epitheca with longitudinal striæ, and usually well-marked annulations and constrictions of growth. No calicular gemmation nor radiceform productions of the epitheca. Calice not oblique, extremely deep, occupying from half to two-thirds of the total length of the corallum, not flattened at the bottom. The interior of the calice shows more or less distinct septal striæ, thirty or more in number. Vesicles small.

The dimensions of an average specimen are: length, eight lines; diameter of calice, six lines; depth of calice, four and a half lines.

There can be no doubt as to the specific distinctness of this form, though the examples upon which it is founded are much silicified, and do not exhibit some points of structure so well as could be desired. *C. Ohioense* is readily distinguished by its uniformly small dimensions, its extraordinarily deep, pointed, and not oblique calice, the presence of distinct

septal striæ, and the absence of radiceform prolongations of the epitheca. The forms to which it is most nearly allied are *C. cylindricum*, Londs., *C. Grayi*, Edw. and H., and *C. sulcatum*, Billings; but the above characters are amply sufficient to distinguish it.

ZAPHRENTIS EDWARDSI, Nicholson.

Plate 23, figs. 6, 6a.

Corallum small, acutely conical, slightly curved towards the base. Length, nine lines; diameter of the calice, six lines. Epitheca with a few obscure annulations of growth, and with well-marked longitudinal striæ corresponding with the septa. Calice circular, about three lines in depth. A well-marked septal fossula on the curved side of the corallum, extending from the center to the margin of the cup, with two smaller and less conspicuous lateral fossulæ, which also extend from the center, and are directed nearly at right angles to the main fossette. The main fossule includes three of the primary septa, whilst the lateral fossules include a single primary septum each. Septa alternately large and small, fifty-six in number altogether. The large septa reach the center of the calice, where they are occasionally slightly bent, but do not unite with one another.

I am reluctant to add to the already long list of species of *Zaphrentis*, but I am unable to refer this to any previously recorded form. It differs from all the known species of the genus, except *Z. Griffithi*, Edw. and Haime, in having two small lateral fossulæ placed at right angles with the main fossule, the latter being deep, extending to the center of the visceral chamber, and situated on the dorsal side of the corallum. From *Z. Griffithi* the present species differs in its smaller size, its proportionately deeper calice, its smaller number of septa, and its much less broadly expanding form.

Position and locality: Corniferous limestone, Columbus, Ohio.

ZAPHRENTIS WORTHENI, Nicholson.

Plate 23, figs. 5, 5a.

Corallum small, conical, strongly curved, the calice being so oblique as to be almost parallel with the long axis of the coral. Length, measured along the greater curvature, fourteen lines; along the smaller curvature,

only five lines. Calice very nearly circular, about ten lines in diameter, shallow, with a single narrow fossule placed on the convex or dorsal side of the corallum. Septa eighty-eight in number; forty-four large, nearly or quite reaching the center; forty-four small, alternating with the former. Epitheca destitute of annulations of growth or accretion-swelling, with fine longitudinal striæ corresponding with the septa.

Apart from its internal characters, *Z. Wortheni* is sufficiently distinguished from all the allied species of *Zaphrentis* by the extraordinary obliquity of the calice, the plane of which forms an angle of no more than twenty degrees, with the tangent to the dorsal surface, where the coral is held upright. Owing to the curvature of the dorsal side, the actual angle formed by the plane of the calice with the axis of the corallum is less than this—probably not more than ten degrees. The species is further distinguished by its narrow fossule, placed on the convex side of the corallum, its small size, the number of the septa, and the absence of annulations or well-marked growth-swellings.

Position and locality: Corniferous limestone, Sandusky, Ohio.

ZAPHRENTIS MULTI-LAMELLATA, Nicholson.

I propose to give this title provisionally to a large form of *Zaphrentis* which appears to me to be undoubtedly distinct, but which is not in such a state of preservation as to admit of a completely satisfactory determination.

The corallum is large, turbinate, and curved towards the base, broadly expanding, its length being three inches and a quarter, and its diameter at the summit about two inches and two-thirds. The epitheca is furnished with shallow annulations of growth, together with longitudinal striæ corresponding with the septa, about five of the latter occupying a space of two lines. The calice and septal fossule are unknown. The septa are sub-equal, extended nearly to the center of the visceral chamber, and somewhat flexuous. Their number, owing to the fact that the calice is mostly filled up with extraneous matter, can not be made out with absolute certainty, but there are about two hundred septa, at a diameter of two inches and a quarter, a little below the calice.

I know of no species of *Zaphrentis* with which this could be compared, its very broadly expanding form and the great number of its septa distinguishing it from all previously recorded species of the genus. It is most nearly allied, perhaps, to *Zaphrentis* (*Heterophrentis*) *spatiosa*, Bill-

ings, but it has more than twice as many septa. More perfect specimens, I feel satisfied, will prove this species to be distinct.

Position and locality: Corniferous limestone, Columbus, Ohio.

ZAPHRENTIS PROLIFICA, Billings.

Zaphrentis prolifica, Billings; Canadian Journal (new series), Vol. IV., p. 121, figs. 22, 23.

Zaphrentis prolifica, Nicholson; Rept. on the Paleontology of Ontario, pl. 3, figs. 2, 2a.

Heterophrentis prolifica, Billings; Canadian Naturalist (new series), Vol. VII., No. 4, March, 1874.

“Corallum simple, turbinate, curved, expanding to a width of from eighteen to twenty four lines in a length of from two to four inches. Surface with a few undulations of growth. Septal striae, eight to ten near the base, and six to eight in the upper part, in a width of three lines. Septa from about one hundred to one hundred and twenty at the margin, where they are all rounded; most common number from one hundred to one hundred and ten. In general they alternate in size at the margin, the small ones becoming obsolete on approaching the bottom of the calice, the large ones more elevated and sharp-edged. The septal fossette is large and deep, of a pyriform shape, gradually enlarging from the outer wall inwards for one-third, or a little more, of the diameter of the coral, at the bottom of the calice. Its inner extremity is usually broadly rounded, or, sometimes, straightish in the middle. It cuts off the inner edges of from eight to twelve of the principal septa, which may be seen descending into it to various depths. The surface layer of the bottom of the cup extends the whole width, bending down a little near the margin, as in *Zaphrentis*, and uniting with the inner wall of the cup all around. It thus seems to represent one of the tabulae of a *Zaphrentis*.” (Billings, Canadian Naturalist, Vol. VII., No. 4, p. 237.) The bottom of the calice is stated to be either smooth or to be furnished with a more or less well-developed pseudo-columella.

Mr. Billings (*loc. cit*) forms a new genus for the reception of this and some allied forms, under the name of *Heterophrentis*. The only characters which are stated to separate this genus from *Zaphrentis* are the existence of a pseudo-columella, and the fact that “there is apparently only a single transverse diaphragm, and this forms the floor of the cup.” I do not feel myself at present in the position to be able to pronounce any opinion as to the validity of the genus thus proposed by Mr. Billings. I shall, however, in the meanwhile leave this pretty little coral in the genus *Zaphrentis*, having myself seen no examples exhibiting the characters quoted by Mr. Billings.

Ordinary examples of *Zaphrentis prolifica* are usually about an inch and a half in length, but vary from three-quarters of an inch up to three inches. The calice is deep, but is exceedingly oblique, its greatest height being on the side of the convex curvature of the coral. The septa are alternately large and small, and the primary septa are always more or less bent as they approach the center. The epitheca, when well preserved, exhibits a few broad and rounded undulations of growth, with more or less distinctly marked longitudinal striæ corresponding with the septa.

Position and locality: Corniferous limestone, Marblehead, Sandusky, Kelley's Island, and Columbus, Ohio.

GENUS ERIDOPHYLLUM, Edwards and Haime, 1851.

(Pol. Foss. des Terr. Pal., p. 423.)

ERIDOPHYLLUM STRICTUM, Edwards and Haime.

Eridophyllum strictum, Edwards and Haime; Pol. Foss. des Terr. Pal., p. 424, pl. 8, fig. 7.

Eridophyllum strictum, Billings; Canadian Journal (new series), Vol. IV., p. 133.

Corallum fasciculate, composed of elongated cylindrical corallites, which have a diameter of from two to nearly five lines, and are placed at intervals apart of about one or two lines. The corallites are strongly annulated by sharp-edged epithecal projections at intervals of from a line and a half to three lines, and at each of the annulations arise small but very conspicuous processes by which the separate corallites are united to one another. Besides the strong periodic annulations, the epitheca is marked by numerous longitudinal striæ, corresponding with the septa. Increase is by calicular gemmation, three or four young being usually produced simultaneously from the parent corallite. A well-marked central tabulate area is present. The septa are well developed in the external area of the corallites, where they are united by delicate dissepiments. There appear to be about sixty septa in a fully matured corallite, but their number could not be ascertained with absolute accuracy, owing to the condition of preservation of the specimens examined.

Milne Edwards and Haime state that the connecting processes between the corallites in this species are only poorly developed, but in such examples as I have seen they constitute a very marked feature, being

usually produced in a whorled manner from the annulations of the corallites.

Position and locality: Corniferous limestone, Columbus, Ohio; also from the same formation at Louisville, Kentucky. Mr. Billings describes the species from the Corniferous limestone of western Canada.

ERIDOPHYLLUM VERNEUILANUM, Edwards and Haime.

Eridophyllum Verneuilanum, Edwards and Haime; Pol. Foss. des Terr. Pal., p. 424, pl. 8, figs. 6, 6a.

Eridophyllum Verneuilanum, Billings; Canadian Journal (new series), Vol. IV., p. 131, fig. 26.

Eridophyllum Verneuilanum, Nicholson; Rept. on the Paleontology of Ontario, p. 35, fig. 7.

Corallum composed of cylindrical, straight, or slightly flexuous corallites, which have a diameter of from four to six lines, and are united by horizontal connecting processes placed at intervals apart of from half an inch to an inch and a half. Septa usually about forty-five in number, alternately large and small, extending very nearly to the center of the visceral chamber, and thus invading the central tabulate area. The septa are united in the outer zone of the corallites by numerous delicate dissepiments. The distance between the different corallites varies much, being sometimes as much as half an inch, whilst at other times the corallites are nearly in contact.

E. Verneuilanum closely resembles *E. strictum*, but the corallites are larger, and are usually more remote from one another, whilst the connecting processes are not only larger, but are also more remote. In the best preserved specimen from Ohio that I have seen the corallites are strongly annulated with periodic growth-swellings, and are close together; thus differing from the typical form of the species, and being distinguished from *E. strictum* by little but the greater size of the corallites and the greater remoteness of the connecting processess. The number of the septa, as pointed out by Mr. Billings, is much larger than that given by Edwards and Haime, viz., twenty-two. On the contrary, there appear to be from forty to sixty septa, alternately large and small, the former nearly or quite reaching the center. The outer area of the corallites is rendered vesicular by the presence of numerous dissepiments, and there is a well-marked central tabulate area. The epitheca is marked with longitudinal striæ corresponding with the septa, and there are also fine encircling striæ.

Position and locality: Corniferous limestone, Columbus, Ohio.

GENUS ACERVULARIA, Schweigger, 1820.

(Handb. der Naturg., p. 418.)

ACERVULARIA PROFUNDA, Hall.

Acervularia profunda, Hall; Geology of Iowa, Vol. I., Part II., pl. 1, figs. 7, 7c.

Corallum sub-hemispheric, astræiform, composed of polygonal, closely united, unequally sized corallites, which vary from less than three to as much as five lines in diameter. Outer walls of the corallites thin; inner calicine wall rarely well defined, the surface sinking, at first gradually and then abruptly, to form the true cup, the diameter of which is always considerable, and varies from one and a half to three lines. The bottom of the true calice is flat or slightly elevated. The septa are about forty, more or less, in number, for the most part extending into the true calice, slender, and marked with denticulations closely resembling those so characteristic of the genus *Heliophyllum*. About six of these denticulations in the space of one line.

Our specimens do not differ in any material respect from those described by Prof. Hall from the Hamilton formation of Iowa. The species is most nearly allied to *A. Davidsoni*, Edw. and H., from which it is distinguished by the smaller size of the corallites as a general rule, the greater inequality in the size of the calices, and the greater number and more conspicuous denticulation of the septa.

Position and locality: Corniferous limestone, Sandusky, Ohio.

ACERVULARIA DAVIDSONI, Edwards and Haime.

Acervularia Davidsoni, Edwards and Haime; Pol. Foss. des Terr. Pal., p. 418, pl. 9, figs. 4, 4b.

Acervularia Davidsoni, Hall; Geology of Iowa, Vol. I., Part II., pl. 1, figs. 8a, 8b.

Coral astræiform, massive, composed of polygonal, unequally sized corallites, the average ones being half an inch in diameter. The walls of the corallites are slightly undulated or zigzagged, and the interior wall is rarely defined. The septa are usually forty or forty-two, with finely denticulated edges, about six or seven denticulations in the space of one line.

The only example of this species which I have seen from the State of Ohio is a polished specimen, which does not exhibit the characters of

the exterior surface. The chief character which separates such a specimen from *A. profunda*, Hall, is the larger size of the corallites, which vary from three to ten lines in diameter, and the zigzag undulations of the outer walls.

Position and locality: Corniferous limestone, Sandusky, Ohio.

GENUS SYRINGOPORA, Goldfuss, 1826.

SYRINGOPORA MACLUREI, Billings.

Syringopora tubiporoides, Billings; Canadian Journal (new series), Vol. IV., p. 115, fig. 17.

Syringopora Maclurei, Billings; Ibid., Vol. V., p. 258.

Syringopora Maclurei, Nicholson; Rept. on the Palæontology of Ontario, p. 41.

Corallum of long, slightly flexuous corallites, which have a diameter of from a line to as much as a line and a half, and which may be nearly in contact, or may be separated by intervals of from two to four lines apart. The connecting processes are usually short and inconspicuous, and often look like mere inosculation of the adjacent corallites, their distance apart varying from three lines to as much as one inch. Epitheca with numerous encircling striæ, and occasionally with obscure longitudinal striæ in addition.

This species is most nearly allied to *S. perelegans*, Billings, from which it differs in its more robust, more flexuous and less regularly disposed corallites, and in the less highly conspicuous connecting processes. The specimens from Ohio are quite similar to those from Canada, except that they are perhaps slightly more regular in their growth than is usually the case with the latter.

Position and locality: Corniferous limestone, Sandusky, Ohio.

GENUS PHILLIPSASTRÆA, D'Orbigny, 1849.

(Note sur des Polypiers Fossiles, p. 2.)

PHILLIPSASTRÆA GIGAS, Dale Owen.

Astræa gigas, Dale Owen; Geol. Survey Iowa, etc., p. 70, pl. 14, fig. 7, 1844.

Phillipsastræa gigas, Billings; Canadian Journal (new series), Vol. IV., p. 128.

Corallum forming large spherical or hemispherical masses, the surface of which is covered with corallites averaging about one inch in diameter. The width of the calices is from five to six lines, and the corallites are destitute of walls and united with one another by the confluence of

their septa throughout their entire height. The number of the septa appears to be about fifty, rising to fifty-six, and they carry arched striae on their sides and spine-like processes on their edges, as is the case in the genus *Heliophyllum*.

All the examples I have hitherto seen of this species are more or less imperfectly preserved, and do not show minute details of structure in a satisfactory manner. The species is, however, readily distinguished from its companion form, *P. Verneuilli*, Edw. and H., by its much larger corallites.

Position and locality: Corniferous limestone, Erie county, Ohio.

DESCRIPTIONS
OF
AMORPHOZOA FROM THE SILURIAN AND DEVONIAN
FORMATIONS.

BY
H. ALLEYNE NICHOLSON.

AMORPHOZOA FROM THE SILURIAN AND DEVONIAN FORMATIONS.

AMORPHOZOA.

GENUS STROMATOPORA.

The genus *Stromatopora* comprises a number of somewhat enigmatical fossils from the Silurian and Devonian formations which have sometimes been referred to the Sponges, sometimes to the *Foraminifera*, and sometimes to the true Corals, though there can be little doubt as to their truly belonging to the first of these. The form of the fossils placed under *Stromatopora* is not constant, though they usually occur as smaller or larger spheroidal, pyriform, depressed, or amorphous masses, which sometimes attain a very considerable size. At other times they present themselves as more or less extensive, thinner or thicker expansions, the under side of which is furnished with an epitheca. Whatever may be their shape and size, the fossils properly referred to *Stromatopora* all agree with one another in their intimate structure. They all consist, namely, of a system of calcareous laminæ, which are disposed concentrically round one or more imaginary centers in the massive species, and are successively superimposed in sheets parallel with the upper and lower surfaces in the expanded forms. The concentric or horizontal laminæ are separated by interlaminar spaces, which are crossed by numerous delicate perpendicular pillars or calcareous dissepiments, so that the entire mass, when viewed in vertical section, appears to be composed of rows of quadrangular compartments or cells. The concentric laminæ, further, are perforated in many, if not in all the species of the genus, by minute rounded or sinuous apertures or pores, by means of which the successive interlaminar spaces are placed in communication with one another. Lastly, in many, if not in all cases, the surface of the mass can be shown to exhibit a comparatively small number of large, rounded apertures, leading down into canals which perforate its substance.

Upon the whole, I can not doubt that the structures above-mentioned as characteristic of *Stromatopora* are such as to necessitate the reference of the genus to the Calcareous Sponges, rather than to either the *Foraminifera* or the *Cœlenterata*. The concentric or horizontal laminæ and the

vertical dissepiments represent two intersecting series of spicules, which are more or less completely amalgamated with one another. The minute crowded perforations, which pierce the concentric laminæ and place the interlaminar spaces in communication, may be regarded as representing the inhalant apertures or "pores" of a sponge; whilst the large superficial openings, and the large canals connected therewith, can hardly correspond with any thing else than the exhalant apertures or "oscula" and the excurrent canals of an ordinary sponge.

The Devonian rocks of Ohio, like those of the same age in Canada, yield a number of large and interesting forms of *Stromatopora*, of which most appear to be new. They also yield examples of certain related forms, which I shall describe as a new genus, or sub-genus, under the name of *Syringostroma*. Lastly, I have found it necessary to establish another genus, or sub-genus, which I have named *Dictyostroma*, for the reception of an extra-limital form from the Niagara limestone, which I have introduced here on account of its affinity to the preceding.

STROMATOPORA PONDEROSA, Nicholson.

Plate 24, figs. 4, 4b.

. Sarcodeme forming a large sub-spherical mass, composed of numerous calcareous laminæ disposed concentrically round an imaginary center, about nine of them occupying the space of one line. Interlaminar spaces crossed by delicate vertical dissepiments, of which about five occupy the space of one line. Surface undulated with numerous irregular rounded prominences, which vary in height and in remoteness, but which have not their summits perforated by any apertures. These prominences, as well as the surface between them, are covered by small rounded tubercles, the apices of which are in many instances clearly perforated by small circular openings. About six of these tubercles occupy the space of one line; they are about one hundredth of an inch in height, separated from one another by about their own width, and they are always distinct and do not coalesce or inosculate with one another. The surface also exhibits a few large circular apertures, which are irregularly distributed in small groups, and have a diameter of from one to two lines. These large apertures have not elevated lips, but are flush with the general surface, and they are the openings of large cylindrical canals which perforate the substance of the mass.

This remarkable species is nearly allied to *S. tuberculata*, Nich., from which, however, it is distinguished by the following characters: 1. In-

stead of forming extended crusts, as the latter species does, *S. ponderosa* constitutes a ponderous and compact sub-spheric mass. 2. The surface is not simply undulated, but exhibits also prominent, rounded, nipple-shaped eminences, the disposition of which is very irregular. 3. The large apertures ("oscula") are much larger than they are in *S. tuberculata* (twice the size or more), and are arranged in small groups of two or three. 4. The tubercles which cover the surface are smaller, and are always distinct and separate from one another. 5. The laminated tissue is closer, and the concentric laminæ more delicate.

There can be little doubt as to the propriety of referring *S. ponderosa* to the Sponges. The surface not only exhibits groups of large rounded apertures or "oscula," but also numerous minute openings perforating the surface-tubercles, and doubtless corresponding with the "pores." The perforation of the surface-tubercles would lead to the supposition that the similar eminences in *S. tuberculata* (as I previously conjectured) are likewise perforated, and are also of the nature of "pores." This supposition, however, does not rest upon the analogy derived from *S. ponderosa*, for I have recently obtained magnificent specimens of *S. tuberculata* showing that many of the surface-tubercles have their apices very distinctly perforated.

The only specimen which I have seen of *S. ponderosa* is a large sub-spherical mass, cut in half and polished on one side. The mass is imperfect, but its vertical height is over five inches, and its transverse diameter must have exceeded half a foot when complete. Its base is broken, and its method of attachment is therefore unknown. The surface exhibits nine oscula, arranged in two groups, which are placed about an inch and a half apart.

Position and locality: Corniferous limestone, Kelley's Island, Ohio.

STROMATOPORA CONCENTRICA, Goldfuss. (?)

Stromatopora concentrica, Goldfuss; Petref., pl. 8, fig. 5.

Stromatopora concentrica, Phillips; Pal. Foss., pl. 10, fig. 28.

Stromatopora concentrica, McCoy; Pal. Foss., p. 65.

The Corniferous limestone of Ohio yields specimens which may with much probability be referred to this classical species, but as the examples in question exhibit no part of the actual surface, any thing like absolute certainty of identification is rendered an impossibility. The reticulation and lamination of the specimens would, however, agree tolerably with that of *S. concentrica*, Gold. (though not so coarse), and the various

layers wrap round one another smoothly, without exhibiting any prominences, tuberculated surfaces, or mammillations. There are about five laminæ in the space of one line; the vertical dissepiments are very slender, and often do not pass completely from one laminæ to another, and the vesicular compartments or cells open on the surface of each laminæ by crowded and very minute rounded or vermicular perforations.

Position and locality: Corniferous limestone, Kelley's Island, Ohio.

STROMATOPORA SUB-STRIATELLA, Nicholson.

Plate 24, figs. 5, 5a.

Sarcodeme forming a large sub-spherical mass, composed of very delicate concentric layers, of which about eight occupy the space of one line. Vertical dissepiments very slender, often incomplete; about ten to fourteen cells in the space of one line. Surface of the mass smooth, non-tuberculated and non-granulated, without eminences of any kind. The concentric laminæ are perforated by exceedingly minute, pin-like, or vermicular perforations, which are arranged so closely as to give to the surface a nebular appearance, and which permit the different strata of cells to communicate with one another. In addition to these very minute openings, the surface shows a number of larger apertures, of a circular form, and varying in diameter from a quarter of a line to half a line, and placed at intervals apart of from two to six lines, though sometimes closer. These openings are not elevated above the general surface, and they are the mouths of canals leading down into the interior of the mass. They are doubtless of the nature of "oscula."

The specimen from which the above description is taken is a sub-hemispheric mass, growing upon a large Brachiopod, and strongly arched above. Its height is about four inches, and its diameter at the base three inches.

I have some hesitation in separating this form from the Silurian *S. striatella*, D'Orb., of which it may ultimately prove to be only a variety. The lamination of *S. striatella*, however, is considerably finer—eleven to twelve layers occupying the space of one line—whilst the comparatively large and remote oscula of *S. sub-striatella* can hardly be supposed to be identical with the tubes described by McCoy (Pal. Foss., p. 13) as traversing the laminated tissue of the former species. This eminent palæontologist states that in *S. striatella* the "upper and under surfaces of slightly weathered specimens" exhibit "vertical vermicular perfora-

tions, about one-fourth of a line in diameter, passing nearly at right angles through the numerous layers composing the mass, at intervals varying from one to two lines apart."

From the other recorded species of *Stromatopora* the present species is readily distinguished by its massive and rounded form, its smooth surface, remote oscula, and the characters of the lamination.

Position and locality: Corniferous limestone, Marblehead, Ottawa county, Ohio.

STROMATOPORA NODULATA, Nicholson.

Plate 24, figs. 3, 3b.

Sarcodeme forming an irregular mass, the precise form and dimensions of which are unknown, though it evidently attained a great size. The mass is composed of concentric laminae of great thickness, from four to six occupying the space of one line. The interlaminar spaces are proportionately reduced in height, and are crossed by calcareous pillars, which give rise to a number of little oval or circular compartments, about six of which occupy the space of one line. Both the horizontal laminae and the vertical pillars are, however, so thick that the cellular compartments produced by their intersection are reduced to minute rounded cells of unequal sizes in successive layers. The compartments or cells are usually placed successively, one above another, in vertical rows, giving the section of the fossil a very characteristic appearance. The surface of the mass (which does not seem to be the true surface) is covered with large and close-set, regularly disposed, nipple-shaped or conical eminences, which are arranged in diagonal lines, each having a height of two lines, and a diameter at the base of about five lines, and being placed about one line apart at their bases. Similar mammillated surfaces occur throughout the mass at different levels. These large and regular rounded elevations show no sign of being perforated at their summits by any apertures of sufficiently large size to be considered as "oscula," nor are any traces of such to be detected elsewhere. The entire surface, however, both generally and of the mammillations, is covered with very minute rounded or elongated perforations, which have often a sinuous or vermicular form, and appear to lead into the successive interlaminar cells. These minute pores are not only extremely small, but are excessively crowded, and on the elevations above spoken of they are arranged more or less in lines radiating from the summit. Except for these perforations, the surface is smooth, and there are no tubercles or granules.

The specimen from which the above description is taken is imperfect, but forms a nearly plain mass, about half a foot in length by four inches in width, and about one inch and a half in thickness. The specimen does not, however, exhibit the margins, the true surface, or the under side, and the entire mass must, therefore, have been of very large size.

The density of the vesicular tissue of this species is so great, and the cellular compartments are so reduced in size, that it may, perhaps, be properly regarded as belonging to the genus, or sub-genus, *Syringostroma*, rather than to *Stromatopora* proper. I can not, however, discover that the mass is permeated by any system of canals running parallel with the surface, and I have, therefore, retained it in the meanwhile in *Stromatopora*.

In some respects *S. nodulata* resembles certain of the forms included by Goldfuss under the name of *Stromatopora polymorpha*; but the description of the internal structure of this species is too insufficient to allow of any comparison, whilst Goldfuss has clearly included more than one form under this head. The present species, also, is distinguished by exhibiting no perforations at the summit of the nipple-shaped superficial prominences, by the fact that the eminences in question are perfectly regular in size and arrangement, and by the great dimensions of the entire mass.

The characters which distinguish *S. nodulata*, when taken in combination, may be summed up as follows: 1. The laminae and vertical rods are so thickened as to reduce the size of the cellular compartments of the organism to a great extent, and the cells are generally placed one above the other in more or less regular vertical lines. 2. The cells of each successive layer open into those of contiguous strata by means of closely approximated rounded or sinuous perforations, the cells of the uppermost layer doubtless communicating in a similar fashion with the exterior medium. 3. The surface is not tuberculated or granulated, but is smooth, and is covered with numerous large rounded or nipple-shaped elevations, which are very uniform in size and height, and are disposed in diagonal lines placed at small intervals apart. 4. The eminences just mentioned are not perforated by any openings other than the minute ones which closely cover the entire surface; and there have, therefore, been hitherto detected no traces of "oscula" or exhalant apertures. At the same time, such apertures doubtless existed, and will be found in more perfect examples. 5. Surfaces covered with the nipple-shaped eminences above spoken of occur at various levels throughout the mass, which would thus appear to have increased in size by the periodic formation of con-

centric crusts. 6. The entire organism must have attained a very large size.

Position and locality: Corniferous limestone, Kelley's Island, Ohio.

GENUS SYRINGOSTROMA, Nicholson.

Sponge-mass calcareous, massive, composed of concentric laminae and vertical pillars, which are so thickened and so amalgamated with one another as to leave nothing but the most minute rounded cells. Laminated tissue traversed by numerous irregularly disposed horizontal canals, which run parallel with the general surface, and are of comparatively large size. Surface exhibiting more or less distinct rounded or vermicular apertures of small size.

The fossils which I have included under this head may, perhaps, constitute only a sub-genus of *Stromatopora*, but I have thought it best to separate them in the meanwhile as a distinct genus. They agree with the species of *Stromatopora* in their general form, and in the fact that their structure is composed of laminated tissue; but this tissue is extraordinarily close and dense, and it is traversed by numerous irregular horizontal canals or tubes, which run approximately parallel with the surface, and which constitute a most conspicuous feature. Nothing of this nature can be detected in the species of *Stromatopora* proper.

The two following species of *Syringostroma* have come under my notice as occurring in the Corniferous limestone of Ohio.

SYRINGOSTROMA DENSA, Nicholson.

Plate 24, figs. 2, 2b.

Sarcodeme apparently forming irregular masses or thick crusts, composed of an exceedingly dense calcareous tissue containing very minute cells. This tissue is probably essentially composed of successive concentric laminae, separated by vertical dissepiments; but its density is so great that it may be regarded in practice as a mass of laminated calcareous matter in which excessively small but numerous cellular compartments are excavated. Not only are these cells extraordinarily small, but they are only now and then arranged in horizontal lines, and they often assume the form of minute tubuli passing through more than one layer. Hence it is impossible to count the number of laminae or rows of cells in a given vertical space, and it can only be said that the mass is denser and the cells more minute than in any known species of *Stromatopora*, whilst, nevertheless, the composition of the whole out of concentric

laminae is very conspicuous. The mass is traversed by numerous very irregularly disposed horizontal canals which run nearly parallel with the surface, have a diameter of usually from one-fifth to one-fourth of a line, and are placed at intervals apart of from one-third of a line to about one line. The upper surface exhibits two distinct sets of apertures—*firstly*, a series of very minute and crowded perforations, which doubtless correspond with the cells of the mass; and, *secondly*, a larger set of apertures, which are very irregularly distributed, and are likewise very numerous. These latter apertures are circular, have a diameter of from one-eighth to one-fifth of a line, are placed at intervals of from one-fourth to one-half line apart, and are almost certainly the apertures of a series of vertical canals.

As regards the additional characters of the surface, the specimens differ so materially that I can not with certainty affirm that they belong to the same species. In the most typical examples the surface is undulating, and exhibits numerous star-like, not elevated, impressions, formed of vermicular bifurcating horizontal canals, which radiate from a central point. When partially decorticated, it is seen that these radiating canals have a distinct calcareous lining, and, whilst in the main horizontal, some of them penetrate the mass obliquely, and thus pass below the actual surface. The diameter of these star-like impressions is about half an inch, or rather less; they are placed close together over the whole surface. Another specimen, very much weathered, shows a smaller number of the above-named stellate impressions, and also exhibits a great number of small circular pits or depressions, from a line to a line and a half in diameter, and placed about their own width apart. The nature of these depressions could not be made out. A third example (like the others, only a fragment, though of large size) exhibits a simply undulated surface, with but obscure indications of any stellate impressions.

All the examples that I have seen of this singular species are fragmentary, and consist of flattened or undulated crusts, three or four inches across, and from half an inch to one inch in thickness. It is quite probable, however, that they are only pieces from the exterior of large spherical or hemispherical masses.

It is possible that the *Stromatopora constellata* of Hall (Pal. N. Y., Vol. II., p. 324, pl. 72, figs. 2, 2b), from the Coralline limestone of Schoharie, may prove, on more minute examination, to be referable to *Syringostroma*; but, in any case, it is clearly distinct from the present species.

Position and locality: Corniferous limestone, Kelley's Island, and Sandusky, Ohio.

SYRINGOSTROMA COLUMNARIS, Nicholson.

Plate 24, figs. 1, 1a.

Sarcodeme forming a sub-spherical (?) mass of large size, composed of extraordinarily delicate calcareous concentric laminae (apparently about twenty in the space of one line), separated by vertical dissepiments. The entire mass is traversed by a series of vertical columns, about half a line in diameter, and placed at distances apart of from one-half to two-thirds of a line, the upper ends of which protrude above the upper surface as a series of small, close-set, rounded elevations or tubercles. Each of these vertical columns is formed by an upward curvature of the concentric laminae of the mass, and is quite solid, the cells and vertical dissepiments being wanting here, and the successive concentric laminae being in actual contact. On the other hand, in the spaces between the columns the concentric laminae are curved downward, and are separated by interspaces crossed by vertical dissepiments. There is thus produced a system of cells similar to those of *Stromatopora* proper, the dissepiments, however, being extremely thick, and the cells extraordinarily minute. Besides the true cells, the intercolumnar spaces show larger circular openings, which usually have a diameter of from one-fourth to one-third of a line, and are the apertures of a series of canals running parallel with the surface. These horizontal canals are irregularly disposed, though often placed in vertical rows, and they are fewer in number than in the preceding species.

The surface is covered with numerous low, rounded elevations, nearly one line in diameter, and placed about half a line apart. The central portion of these elevations is formed by the projection above the surface of the vertical columns before noticed, and round this central area, in the best preserved portions of the surface, is seen a row of minute rounded apertures, which have a diameter of about one-sixth of a line, and are doubtless the openings of a series of vertical canals. There are indications that the surface between the tubercles is perforated with still more minute openings, corresponding with the cellular compartments of the mass, but I have not been able to determine this in a satisfactory manner.

The specimen described is a fragment about six inches long and eight lines in thickness, apparently derived from the exterior of a large mass.

The species can not possibly be confounded with any other, as its characters are entirely unique.

Position and locality: Corniferous limestone, Sandusky, Ohio.

GENUS DICTYOSTROMA, Nicholson.

Sponge-mass forming a polymorphous or hemispherical mass of considerable size, composed of concentrically arranged undulating layers, which surround an imaginary center, but which are not composed of finer laminae. These layers apparently have their substance traversed by horizontal canals, and each sends up from its upper surface a series of prominent, pointed, and apparently hollow processes or papillae, which, without being amalgamated with it, support the layer next above, like so many pillars. The outermost layer of all, forming the exterior of the whole mass, is destitute of these processes, smooth, and apparently solid, except for the presence of irregularly disposed rounded or circular perforations (oscula), which penetrate the mass more or less vertically, and have a comparatively large size.

This genus is nearly allied to *Stromatopora*, especially to such forms as *S. tuberculata*, Nich.; but it exhibits differences which seem to be of generic value. The sarcodeme is composed of concentrically arranged layers, but these are of comparatively enormous thickness, and are not composed of subordinate layers. The concentric laminae, when viewed in section, further exhibit oval or rounded apertures, which appear to be the sections of horizontal tubes. In *Stromatopora*, again, the concentric laminae are traversed by a fine and closely arranged system of vertical and apparently solid dissepiments, which often appear to pass continuously through several layers, and are amalgamated with the laminae which they separate. In *Dictyostroma*, on the other hand, the different layers of which the mass is composed give off from their upper surfaces a series of strong, apparently tubular, more or less vertical pillars or processes, upon the apices of which the next layer above seems to repose, without the occurrence of any direct union between the two, so far as can be determined. Distinct oscula are present in *Dictyostroma*, as in most of the species of *Stromatopora*, but I have detected no evidence of "pores."

The following is the only species of the genus which has come under my notice:

DICTYOSTROMA UNDULATA, Nicholson.

Plate 24, figs. 6, 6c.

Sarcodeme composed of concentrically arranged layers, which have a thickness of nearly one-third of a line, and are separated by intervals of nearly the same width, so that about four layers are present in a vertical

space of two lines. The layers are undulating, and conform in their flexures to one another, and they show no signs of being composed of secondary laminae. They commonly exhibit, however, on their edges what appear to be the mouths of tubes traversing them horizontally. The upper surface of all the successive layers, except the outermost, is studded with pointed or elongated processes, which, when broken across, show a central cavity, and which extend to the under surface of the layer next above. The height of these processes is about one-third of a line, and three or four of them occupy the space of one line. The successive layers rest upon the points of these processes apparently without being united with them. The outermost layer of all is smooth and undulating, and exhibits a few irregularly disposed, circular or oval apertures, which are placed at varying intervals apart, and have a diameter of about one line.

Dictyostroma undulata in appearance resembles a greatly magnified *Stromatopora*; but the differences to which attention has been drawn in the above description seem to be sufficient for its characterization as the type of a new genus.

Position and locality: Niagara group, Louisville, Kentucky. From the cabinet of Prof. Edward Orton. Collected by Rev. H. Hertzner.

DESCRIPTIONS
OF
POLYZOA FROM THE SILURIAN FORMATION.
BY
H. ALLEYNE NICHOLSON.

POLYZOA FROM THE SILURIAN FORMATION.

MOLLUSCA.

POLYZOA.

GENUS *PTILODICTYA*, Lonsdale, 1839.

(Murchison's Sil. Syst., p. 130.)

PTILODICTYA FALCIFORMIS, Nicholson.

Plate 25, figs. 7, 7b.

Polyzoary consisting of a single unbranched, or slightly branched, elongated, flattened, narrow, and two-edged frond, the form of which is more or less curved and falciform, and which gradually expands from a pointed base till it reaches a width of two lines within a distance of less than half an inch above the base. The total length may exceed two inches, but the width rarely or never exceeds two and a half lines. The transverse section is acutely elliptical, the thickness in the middle not exceeding half a line, and the flat faces of the frond are very gently curved, and are not angulated. No central axis can, as a rule, be made out with certainty, though the existence of such can sometimes be demonstrated. The edges of the frond are thin and sharp, formed by a narrow band, which is longitudinally striated, and, when perfect, is perforated by the apertures of minute imperfect cells, which have a longitudinal direction. Both sides of the frond are celluliferous, the cells being apparently perpendicular to the surface, and being arranged in intersecting diagonal lines, which form angles of about thirty degrees with the sides of the frond, and thus cut one another at sixty degrees. The mouths of the cells are oval, or somewhat diamond-shaped, their long axis coinciding with the axis of the frond, alternately placed in contiguous rows, about eight in the space of one line measured diagonally, and ten in the same space measured transversely, the outermost rows very slightly smaller than the others. Walls of the cells moderately thick; no surface-granulations, tubercles, spines, or elevated lines. The mouths

of the cells parallel with the general surface, neither lip being especially prominent, and the plane of the aperture not being oblique.

As a general rule, the polyzoary is simple, unbranched, and falciform. I have, however, seen, in the fine collection of Mr. Dyer, of Cincinnati, some specimens in which the frond bifurcates at its distal extremity, and at least one example in which it splits into three divisions. I have also seen examples of what may prove to be a distinct species, in which the frond is very much wider than is normally the case.

This beautiful form is allied to *Ptilodictya* (*Escharopora*) *recta*, Hall, on the one hand, and on the other hand to *P. lanceolata*, Goldfuss, *P. gladiola*, Billings, and *P. sulcata*, Billings. The specimens from which the above description was taken were sent to me with the label of "*Escharopora recta*" attached to them; and at first sight they closely resemble this species, especially in the disposition of the cells in intersecting diagonals of extreme regularity. It is certain, however, that they are distinct from Hall's species, the chief differences consisting in the fact that the frond of *P. falciformis* is greatly flattened, and is regularly curved and sabre-shaped, instead of being straight, whilst the edges are sharp and longitudinally striated, and carry only a few imperfect cells. On the other hand, the frond of *Escharopora recta* is "cylindrical or sub-cylindrical," instead of having an acutely elliptical transverse section; there do not appear to be any non-poriferous margins; and no mention is made of the striated laminar axis, which is unquestionably present in *P. falciformis*. Hall states that *Escharopora recta* is not branched, but possesses root-like processes. Judging, however, from his figures, it would seem probable that his specimens have been drawn and described in an inverted position, and that the frond is in reality dichotomously branched. (See Pal. N. Y., Vol. I., pl. 26, fig. 1a.)

From *Ptilodictya lanceolata*, Goldfuss (Petref., pl. 37, fig. 2), the present species is readily distinguished by, more especially, the disposition of the cells, which are in regularly intersecting diagonal lines; whereas in the former there is a central series of longitudinally arranged cells, flanked on each side by diagonal rows directed in opposite directions, like the barbs of a feather.

With *Ptilodictya gladiola*, Billings (Cat. Sil. Foss. of Anticosti, p. 10), our species agrees in the shape of the frond; but it is proportionately twice as wide, whilst the cells are oval, instead of being rectangular or oblong, and are disposed in decussating diagonals, instead of constituting longitudinal rows, as in the former species.

Lastly, *Ptilodictya sulcata*, Billings (*loc. cit.*, p. 35), whilst resembling

P. falciformis in shape, is distinguished by the nearly square cells, with intercellular sulci, and by the fact that the cells are arranged in longitudinal lines.

, *Position and locality*: Not uncommon in the Cincinnati group, near Cincinnati. The specimens described are from the cabinet of Mr. U. P. James.

PTILODICTYA EMACERATA, Nicholson.

Plate 25, figs. 5, 5b.

Polyzoary consisting of minute, narrow, linear fronds, which branch dichotomously, and have the form of a much flattened, acutely pointed ellipse in transverse section. Width, one-third of a line; length of largest specimen observed, two lines. Cells elliptical, their long axis corresponding with that of the branches, about six or seven in the space of one line measured longitudinally. There are four, five, or, rarely, six rows of cells in the frond. When four rows of cells are present, the two central rows are longitudinal, and one row on each side is composed of cells directed in an obliquely ascending manner. When there are five rows, as seems to be most commonly the case, the three central rows are longitudinal, and a row on each side is oblique. When there are six rows of cells, two central ones are longitudinal, and two on each side are oblique. The cell-mouths are much longer than wide, and each row is separated from the next by an elevated line. The lateral margin of the frond on each side forms an obtuse non-celluliferous edge, the width of which is so small that it can not always be detected. A central axis was not clearly determined, but such a structure is doubtless present.

The only previously recorded species of the genus with which *Ptilodictya emacerata* presents any close resemblance is *P. fragilis*, Billings, from strata of about the same age in Anticosti (Cat. Sil. Foss. of Anticosti, p. 9). Our species, however, is distinguished from the latter by its uniformly more minute dimensions, the smaller number of rows of cells in the frond, and the possession in general of no more than a single row of oblique cells on each side. *P. fragilis*, on the other hand, has a width of from two-thirds of a line to one line, with from eight to ten rows of cells, and two or three rows of oblique marginal cells on each side. It is possible our form is only a variety of *P. fragilis*; but in the absence of figures of the latter, and in the face of the differences above mentioned, I think it safest, in the meanwhile, to regard *P. emacerata* as a distinct species.

Position and locality: Cincinnati group, near Cincinnati. The specimens described are from the collection of Mr. U. P. James.

PTILODICTYA FLAGELLUM, Nicholson.

Plate 25, figs. 4, 4b.

Polyzoary consisting of a single, narrow, unbranched, two-edged, flattened frond, which has an acutely elliptical section. The frond commences at an attenuated base, and gradually expands till a width of one line is reached, the total length in the only specimen examined being eight lines. The general form of the frond is falciform, but towards the base it is alternately bent from side to side in a flexuous manner. The cells are arranged in longitudinal rows, about ten rows in the space of one line, the cells of contiguous rows alternating with one another. The cell-mouths, when most perfect, are narrow and long-oval; when worn, sub-circular; and the rows of cells are separated by strongly elevated ridges. The non-celluliferous margins of the frond are inconspicuous; and the central axis, though doubtless present, was not clearly determined.

The species most nearly resembles *Ptilodictya gladiola*, Billings, from which it is distinguished by its much smaller size and less width, and by its flexuous form. From *P. falciformis*, Nich., it is separated not only by the above characters, but also by the longitudinal arrangement of the cells.

Position and locality: Cincinnati group, Lebanon, Ohio. Collected by Prof. Edward Orton and Mr. W. H. Bean.

PTILODICTYA (?) ARCTIPORA, Nicholson.

Plate 25, figs. 9, 9b.

Polyzoary forming a cylindrical, slightly branched frond, which is not sharp-edged, exhibits no non-celluliferous borders, and shows no traces of a central laminar axis. Cells arranged in obscurely longitudinal, alternating rows, apparently perpendicular to the surface, and radiating in all directions from an imaginary axis. Cell-mouths very much compressed, much longer than wide, expanded below, and attenuated superiorly, where they are often somewhat twisted and bent. Upon the whole, the cells are pyriform in shape, with their narrow ends directed upwards, about eight in the space of one line measured vertically, and twelve in the same space measured diagonally. The cells are not always in contact, especially in their upper portion, and their borders are always dis-

tinctly marked off by impressed lines; but they are not arranged between elevated longitudinal lines. The margins of the cells are very thick and conspicuous, not granulated, tuberculated, or spinigerous.

The best preserved fragment examined had a length of eight and a half lines, dividing at its summit into two branches, its diameter being rather more than one-third of a line.

From its cylindrical form, and the absence of a laminar axis or of non-poriferous margins, it would seem certain that this singular form is not a *Ptilodictya*; but I am at a loss to know where it should properly be placed, its minuteness rendering it very difficult to make out the details of its internal structure, and thus leaving its generic affinities uncertain. It has, however, some affinity with *Ptilodictya* (?) *raripora*, Hall, from the Clinton group; and I have, therefore, retained it provisionally in this genus.

Position and locality: Cincinnati group, Cincinnati. From the cabinet of Mr. U. P. James.

PTILODICTYA FENESTELLIFORMIS, Nicholson.

Plate 25, figs. 8, 8b.

Polyzoary palmate or sub-palmate towards the base, dividing distally into small branches. Basal expansion and branches flattened and sharp-edged, the branches being acutely elliptical in cross section, and about three-fourths of a line in thickness centrally. Cells covering the whole surface on both sides, with the exception of the sharp lateral margins, and of certain non-poriferous areas to be afterwards noticed. The cells on the two aspects of the flattened frond have their bases separated by a thin laminar axis. The cells in the middle of the frond are about three-eighths of a line in height, gradually diminishing towards the margins. Cell-mouths ovate, slightly longer than broad, arranged in longitudinal rows, alternate or sub-alternate in contiguous rows. About five cells in one line measured longitudinally, and six in the same space measured diagonally. The longitudinal spaces between the rows of cells are broad and slightly elevated, and are faintly striated longitudinally, or obscurely punctate. On the other hand, the spaces between the ends of the cells are very much narrower; and the surface thus closely resembles that of a small *Fenestella*, the cell-mouths looking like "fenestrules," the longitudinal interspaces between the cells representing the "interstices," and the narrow spaces between the ends of the cells corresponding with the "dissepiments." The only specimens examined exhibit numerous,

apparently solid, rounded or stellate areolæ, of an average diameter of two-thirds of a line, which are not occupied by the cells, but which exhibit an obscurely pitted surface.

In its superficial characters this form might readily be taken for a *Fenestella*, whilst the character last mentioned gives it somewhat the aspect of certain species of *Chætetes* (*Monticulipora*). Its internal structure, however, proves it, beyond all question, to be a genuine *Ptilodictya*; and I am not acquainted with any other species of the genus with which it could be confounded.

Position and locality: Cincinnati group, Cincinnati, Ohio. The specimens examined are from the cabinet of Mr. U. P. James.

FENESTELLA NERVATA, Nicholson.

Plate 25, figs. 11, 11a.

Frond fan-shaped, (?) composed of narrow, closely approximated branches, about four or five of which occupy the space of one line. On the non-celluliferous side of the frond are two strong, slightly diverging, rounded ribs, about half a line in diameter, resembling the midribs of a multicostate leaf. From the sides of these ribs the branches spring obliquely, being directed in opposite directions on opposite sides of the rib, with which they make a very acute angle (ten degrees or less). Fenestrules long and narrow, nearly twice as long as wide, about three in the space of one line measured vertically, and five in the same space measured transversely. For the most part, the fenestrules do not alternate in contiguous rows, but are placed opposite to one another. The narrow and rounded dissepiments are thus also placed nearly or quite opposite to each other. Branches faintly striated in a longitudinal direction. Celluliferous side unknown.

The example of this species from which the above description is taken is imperfect, and the ribs from which the branches rise are placed two lines apart near the base, and four lines apart near the summit. It would seem most probable that the ribs spring from a common root, and that there were many of them in the perfect frond. The species is distinguished not only by the possession of these ribs, but also by the long, narrow fenestrules, which are not placed alternately, but are so disposed that the dissepiments connecting contiguous branches become opposite or sub-opposite.

Position and locality: Summit of the Niagara formation (in strata representing the Guelph formation of Canada), Cedarville. Collected by Prof. Edward Orton.

GENUS CERAMOPORA, Hall, 1852.

(Pal. N. Y., Vol. II., p. 168.)

CERAMOPORA OHIOENSIS, Nicholson.

Plate 25, figs. 10, 10c.

Polyzoary incrusting, forming thin expansions attached to the surface of Brachiopods or Corals, and consisting, typically at any rate, of a single layer of oblique cells. Cells arranged in intersecting diagonal lines, and disposed in a somewhat concentric manner round more or fewer central points; their upper walls thin and arched; the cell-mouths oblique, and, when most perfect, semicircular in shape. About eight cells in the space of one line.

Such are the appearances presented by this fossil when quite perfect, and its examination in this condition leaves no doubt as to the propriety of placing it in Hall's genus *Ceramopora*. Worn examples, however, exhibit very different characters, and when the entire original surface has been abraded it is sometimes difficult or impossible to determine whether one is dealing with this or some entirely different form.

When slightly worn, the appearances shown in fig. 10*b* are exhibited. The delicate front wall of the cell has now disappeared, and the cavity of the cell appears to be divided into two distinct compartments, a larger and a smaller, both of a somewhat triangular shape, by an oblique internal septum. Other smaller cavities appear in addition in the walls separating the different cells.

When more deeply worn down, or under certain conditions not clearly understood, the cells (figs. 10*c* and 10*d*) appear in the form of rounded or oval apertures, arranged in diagonal rows, but separated by a vast number of small rounded foramina, which appear to be the mouths of interstitial tubuli. In this condition the fossil presents much the appearance of certain species of *Chætetes* (*Monticulipora*).

The best examples of this singular Polyzoon that I have seen grow in the form of thin crusts, rarely exceeding one-fourth of a line in thickness, upon *Strophomena alternata* and upon various species of *Chætetes*. In some examples, it would seem that several layers of cells are superimposed on one another; but I do not feel satisfied as to the real nature of these specimens. Not uncommonly the cells are concentrically disposed round a number of irregular areolæ, each of which is formed by a number of cells radiating from a central point. Young examples form circu-

lar crusts, with a slightly cupped center, from which the cells radiate in every direction. Lastly, examples are not uncommon which appear to have the form of small branching stems. Some of these, certainly, are merely constituted by thin crusts growing upon various ramose species of *Chaetetes*. Others, however, appear to be entirely composed of the Polyzoon itself, without the intervention of any foreign body; and it is possible that these will eventually prove to be a distinct species.

Position and locality: Cincinnati group, Cincinnati. The specimens described are from the cabinet of Mr. U. P. James.

GENUS ALECTO, Lamouroux, 1821.

ALECTO FRONDOSA, James.

Plate 25, figs. 3, 3b.

Aulopora frondosa, James; named, but not figured or described, in the Catalogue of Lower Silurian Fossils of the Cincinnati group, 1871.

Polyzoary creeping, adnate, of reticulating and anastomosing branches, which sometimes become more or less completely confluent, and thus give rise to a thin expanded crust, or which may be partially reticulated and partially confluent. When the branches form a network, the meshes are usually extremely variable in size and disposition, but they are in general more or less oval, and have a long diameter of from half a line to a line or more. The cells are uniserial on the narrowest branches, but biserial, triserial, or multiserial on other parts of the cœnœcium; elongated and tabular, immersed below, but free towards their aperture, the terminal portion of the tube being more or less elevated above the general surface. Cells from six to eight in the space of one line. Cell-mouths terminal, circular, of the same diameter as the tube.

There does not appear to be any reason for doubting that this is a true *Alecto*. It is nearly allied to *A. auloporoides*, especially as regards the size and form of the cells; but the greater width of the branches, and their common coalescence into crusts, together with the greater number of the rows of cells over most parts of the cœnœcium, communicate to the fossil quite a peculiar appearance, and appear to be characters of specific value. The above description is drawn from type specimens kindly furnished by Mr. U. P. James. The examples that I have seen are parasitic upon the valves of *Orthis* and *Strophomena*, and upon various species of *Chaetetes*.

I have seen one specimen, in the collection of Mr. Dyer, of Cincinnati, in which the spaces between the cells are very minutely porous or tubular, and I am informed by Mr. James that a similar specimen exists in his cabinet. It is possible these may constitute a distinct species.

Position and locality: Cincinnati group, Cincinnati, Ohio.

ALECTO AULOPOROIDES, Nicholson.

Plate 25, figs. 2, 2b.

Polyzoary creeping, adnate, of narrow branches, which divide at more or less acute angles, and repeatedly inosculate, so as to give rise to a complicated network, the meshes of which are usually more or less elliptical, and have a long diameter of one line, less or more. Cells tubular, partially immersed, but free close to their apertures, sometimes uniserial, but more commonly arranged in two alternating rows, and sometimes irregularly disposed at the points of anastomosis of the branches. About six or seven cells in the space of one line. Cell apertures terminal, circular, of the same diameter as the tube, the last portion of the cell being more or less conspicuously elevated above the general surface.

This form seems to have been usually regarded as identical with *Aulopora arachnoidea*, Hall, to which it bears a considerable superficial resemblance; but it is certainly distinct, and it seems to me to be an unequivocal *Alecto*. It is nearly allied to *A. frondosa*, James, from which it is distinguished mainly by its much more slender habit and graceful form, and by its generally having its cells arranged in a single or double series.

Position and locality: Cincinnati group, Cincinnati, growing upon *Strophomena alternata*, Conrad. Collected by Prof. Edward Orton and Mr. U. P. James.

ALECTO CONFUSA, Nicholson.

Plate 25, fig. 6.

Polyzoary adnate, forming thin crusts, which envelop foreign bodies. Cells tubular, multiserial, arranged in irregular transverse rows, immersed towards their bases, free and elevated above the surface towards their mouths. Cell apertures circular, terminal, of the same diameter as the tube, about five in the space of one line.

All the examples of this species that I have seen are parasitic on the

columns of Crinoids, which they closely embrace and incrust; and they might readily be mistaken for a species of *Aulopora*, unless care were exercised. The species is nearly allied in essentials to the two preceding; but it is distinguished by its constantly forming thin crusts, by its larger, more prominent, and more closely and irregularly arranged cells.

Position and locality: Cincinnati group, Cincinnati. Collected by Mr. U. P. James.

HIPPOTHOA INFLATA, Hall.

Plate 25, figs. 1, 1b.

Alecto inflata, Hall; Pal. N. Y., Vol. I., p. 77, pl. 26, figs. 7a, 7b.

Polyzoary creeping, adnate, branched, and forming a close but irregular network. Branches linear; cells uniserial, pyriform, each springing by a contracted base directly from the cell below; about four cells in the space of one line. Cell-mouths smaller in diameter than the expanded end of the cell, sub-terminal, and placed more or less distinctly on the front face of the cell.

Though in some respects resembling some of the species of *Alecto*, I think there can be no hesitation in referring this beautiful species to the genus *Hippothoa*, Lamouroux, with which it agrees in the form of the cells and the position of the cell-mouths. It is very readily distinguished from the species of *Alecto* just described, by the fact that the cells are not at all immersed, by the fact that each cell springs directly from another, by the cells being strictly uniserial, and by the position of the cell-mouth on the front face of the swollen cell. The cells are distinctly pyriform in shape, attenuated below, with a smooth surface, the aperture being orbicular or oval and destitute of notches or spines. The network formed by the polyzoary is usually a very close one, the branches being given off from the sides of the cells, usually at intervals of from half a line to two-thirds of a line.

All the examples of this species which I have seen are parasitic upon *Strophomena alternata*. Hall's specimens are from the Trenton limestone. but there can be no doubt as to their identity with ours.

Position and locality: Cincinnati group, Cincinnati. Collected by Prof. Edward Orton and Mr. U. P. James.

A REPORT

ON SOME OF THE

INVERTEBRATE FOSSILS OF THE WAVERLY GROUP
AND COAL MEASURES OF OHIO.

BY

F. B. MEEK.

To DR. J. S. NEWBERRY, *State Geologist*:

DEAR SIR: I herewith respectfully submit a report on some of the Invertebrate fossils collected by the State Geological Survey of Ohio from the subdivisions of the Carboniferous system known as the Waverly group and Coal Measures. Preliminary notices of some of these fossils were published, without illustrations, a few years back, in the Proceedings of the Academy of Natural Sciences at Philadelphia; and the drawings of those here illustrated were subsequently prepared, and are now presented along with somewhat more extended descriptions. At the time these drawings were made, it was intended to give more full illustrations of the fossils of these formations, particularly of the *Brachiopoda* of the Waverly group, which contains numerous invertebrate remains that are not here included. As the report on these fossils, however, was not to be published until that on some of those of the older rocks was issued, work on the former was mainly suspended after the preparation of the drawings now submitted, my attention being for some time after devoted to the preparation of the published report on some of the Ohio Silurian and Devonian fossils, and preparing reports on collections of several General Government Surveys of the Western Territories.

A short time before the published report mentioned above was sent to the printer, I was prostrated by a severe and protracted attack of sickness, that not only prevented me from superintending the publication of the same, but caused an entire suspension of work on the Waverly and Coal Measure fossils. A few of the plates of the latter report, however, were already engraved; but when the others were called for I was only able to arrange such drawings as were at that time prepared, without regard to the original plan, and even without adding others necessary to the complete illustration of some of the species.* This explanation is made in order that those who use this report may understand why the plates were not more systematically arranged. The original plan was, that the space between the plates now numbered 10 and 14 was to be occupied by two or more plates of *Brachiopoda*, with numbering of the whole made to correspond, while the plate now numbered 13, and only partly occupied by Lamellibranchs, was intended to be filled out with the same, and inserted between the plates now numbered 15 and 16. As this, however, for the reasons already explained, could not be done, the intervening space had to be filled with figures of Crinoids described by other parties, which latter figures would have been more systematically placed on plates preceding all the others.

Had health permitted the completion of the original plan of a thorough study of the invertebrate fossils of the Waverly group, I had intended to prepare for this place some general remarks on the relations of this fauna to those of the Carboniferous and Devonian rocks of other parts of this country and Europe, for which purpose some notes were from time to time prepared. Nothing of this kind, however, will now be attempted here, though it may be proper to remark that I have seen no reason to change an opinion long since expressed in a joint paper with Prof. Worthen, that this rock and its equivalents in Illinois, Indiana, etc., belongs to the Carboniferous

* This is all the more to be regretted because better specimens of some of the species than those seen by me have doubtless since been found.

system.* It may also be added that, from the first, I have been impressed with the rather curious fact that many of the Waverly fossils have much more closely allied representatives in the Coal Measures of our Western States than are yet known to occur in the Lower Carboniferous limestones of the same region. Quite a list of very closely allied representative forms from these two horizons might be made out, mainly of species belonging to the *Polyzoa*, *Brachiopoda*, *Lamellibranchiata*, and *Crustacea*. By these remarks, however, it is not intended to be even intimated that I have the slightest suspicion that the Waverly should be included in the Coal Measures. It is only an interesting instance of somewhat similar physical conditions having brought into existence similar forms in particular kinds of life at different periods of time.† On the other hand, the *Crinoids* of the Waverly correspond closely in their general features to those of the the Lower Carboniferous limestones of the West, while the *Cephalopoda*, particularly the *Goniatites* and *Nautili*, nearly approach European Lower Carboniferous forms.

In preparing this report, I have been favored by Prof. Henry with the usual facilities at the Smithsonian Institution. I am also under obligation to Prof. Winchell for access to his types of the fossils described by him from the horizon of the Waverly rocks in Michigan, and for the privilege of making tracings of the drawings of his species, so far as completed. I only regret that circumstances prevented a direct comparison of specimens, especially in some doubtful cases that have come up for decision since I saw his collection. For the use of some of the fossils figured in this report I am indebted to the Rev. Mr. Hertzner, Prof. Andrews, and Mr. Klippart, of Columbus, from whose private collections they were borrowed. The drawings for the accompanying plates were made by Messrs. W. H. Holmes, I. C. McConnel, and H. W. Elliott, of Washington City, D. C.

Very respectfully, yours,

F. B. MEEK, *Palæontologist*.

* Am. Jour. Sci. and Arts, Vol. XXXII., page 167, 1861.

† Although the Waverly group is not a coal-bearing formation, it agrees *much* more nearly with the Coal Measures, *lithologically*, than with the Lower Carboniferous limestones further westward, and hence was apparently deposited under local conditions more nearly corresponding to the Upper than to the Lower Carboniferous, though belonging to the age of the latter.

WAVERLY GROUP SPECIES.

MOLLUSCA.

POLYZOA.

GENUS FENESTELLA, Lonsdale, 1837.

(Murchison's Sil. Syst., 676.)

FENESTELLA DELICATA, Meek.

Plate 10, figs. 2a, b, c, d.

Fenestella delicata, Meek (1871); Proceed. Acad. Nat. Sci., Philad., XXIII., 159.

Polyzoum growing in flat flabelliform, very finely reticulated expansions; branches very slender, rigid, bifurcating, and often nearly parallel, or gradually diverging, to give room for new ones formed by division; dissepiments about half as thick as the branches, alternating or opposite, and but little expanded at the ends, as seen on the non-poriferous side; fenestrules very uniform, oblong, with length usually about one-third to one-half greater than their breadth; non-poriferous side roughened by little nodes along the branches, rather more closely arranged than the fenestrules; poriferous side with a similar row of little pointed elevations along a more or less defined mesial ridge of each branch; pores comparatively large, alternating, and numbering two, or occasionally three, in each row opposite each fenestrule, and one generally nearly or exactly at one or both ends of each dissepiment.

Size of entire polyzoum unknown, but it apparently attained a length of three inches or more; number of fenestrules in 0.20 inch, measuring longitudinally, 3; do., measuring transversely, 4.

As seen on the non-poriferous side, this species closely resembles Prof. McCoy's figure of his *F. plebeja*, natural size, excepting that it forms a slightly finer network. Under a magnifier, however, it is seen to differ in having a row of little nodes along each branch, and I have not seen any longitudinal striæ on its branches, though they probably exist on perfect specimens. The magnified figures of the poriferous side of *F. plebeja* show still more important differences, its fenestrules being proportionally much longer, with four or five pores opposite each side. The

little nodes or projecting points along the mesial ridge of this side of the branches in our species do not exist in *F. plebeja*, nor does the latter usually have a pore opposite each end of each dissepiment, as in the species under consideration.

Locality and position: Lodi, Ohio. Waverly group of Lower Carboniferous.

FENESTELLA MULTIPORATA? var. LODIENSIS.

Plate 10, figs. 1a, b, c.

Fenestella multiporata, McCoy (1844); Synop. Carb. Foss. Ireland, p. 203, pl. 28, fig. 9.

Polyzoum flabelliform; stems slender, bifurcating, sometimes straight, and running nearly parallel to each other, but in other examples curving laterally to make room for new divisions, or somewhat flexuous; dissepiments very slender or scarcely half as thick as the stems, and very little or not at all expanded at the ends; fenestrules two or three times as long as wide, and not rounded at the ends; pores situated on little prominences, and alternately arranged so that from five to seven of them may be counted on each side of a stem opposite each fenestrule; mesial ridge between the rows of pores very small or apparently sometimes obsolete, occasionally with little prominences about twice as distant from each other as those bearing the pores; non-poriferous side of the stems rounded, or sometimes sub-angular, and minutely striated longitudinally.

Entire size of polyzoum unknown, but apparently sometimes not less than four or five inches in diameter. Fenestrules 7 to 9 in 0.20 inch, measuring transversely, and about 2 to 3 in the same space, measuring longitudinally; number of pores in same space on each side of a stem, 16 to 17.

This fossil agrees so exactly in the size of its branches, dissepiments and fenestrules, and so nearly in the nature and arrangement of its pores, with *F. multiporata* of McCoy, that I am inclined to believe it may possibly be a variety of the same species. The only differences I can see are, that it seems to be nearly destitute of the mesial carina so well developed along the poriferous side of the branches in Prof. McCoy's species, and the somewhat greater obliquity and prominence of its pores, which also usually number one or two less on each side, opposite each fenestrule, than in *F. multiporata*. It likewise shows some appearances of little nodes along the middle of the poriferous side of the branches not represented in the latter. It is probably a distinct species, but I prefer to

place it as a variety of *F. multiporata* until its relations to that form can be determined by a comparison of authentic specimens.

Locality and position: Lodi, Ohio. Shaly beds of the Waverly group.

BRACHIOPODA.

GENUS LINGULA, Bruguere, 1792.

(Encyc. Meth. Tab., 250.)

LINGULA (LINGULELLA ?) MEMBRANACEA, Winchell.

Plate 14, fig. 4.

Lingula membranacea, Winchell (1863); Proceed. Acad. Nat. Sci., Philad., XV., 3.

Shell attaining about a medium size, compressed, longitudinally oblong, with length nearly twice the breadth, and lateral margins almost straight and parallel, or but very slightly convex in outline; anterior margin rounded or sometimes faintly subtruncated; beak very obtuse, with a narrow faint ridge extending from it a short distance forward. Surface appearing smooth, but on close examination showing very obscure traces of fine concentric striæ.

Length, 0.78 inch; breadth midway between the front and middle, 0.45 inch; do. at same distance from anterior end, 0.42 inch.

The specimen from which our figure and description were prepared seems to be mainly an internal cast of the dorsal valve, judging from the obtuseness of the beak. The little ridge extending forward from the beak has somewhat the appearance of being the cast of a small furrow of the cardinal margin, for the passage of the peduncle. If this appearance is not deceptive, the species would doubtless fall into Mr. Salter's group *Lingulella*. In our figure this little ridge is represented slightly too thick, and scarcely long enough, while the lateral margins of the figure are also a little too straight, and its anterior region scarcely wide enough, proportionally.

This seems to be a marked form, readily distinguished by its longitudinally oblong form, nearly straight and parallel sides, and compressed valves.

I have not had an opportunity to compare our specimens with Prof. Winchell's types, but our shell agrees so nearly with his description that I am inclined to believe it belongs to his species.

Locality and position: Prof. Winchell's type specimens came from the yellow, fine, arenaceous beds under the Burlington limestone, at Burlington, Iowa, belonging to the horizon of the Waverly group of Ohio, while that we have figured was found at about the same horizon, at Hart's Grove, Ashtabula county, Ohio.

LINGULA MELIE, Hall?

Plate 14, fig. 3.

Lingula melie, Hall (1864); 16th Report of the Regents on the State Cab. Nat. Hist. N. Y., 24; and (1867) Palæont. N. Y., IV., 14, pl. 1, figs. 3 and 4.

Shell narrow-subovate or sub-elliptic, moderately convex, widest at or a little in front of the middle, where the breadth equals about one-half to two-thirds the length; lateral margins forming semi-oval or nearly semi-elliptic curves, and rounding rather abruptly into the subtruncate or rounded front; beaks obtuse, with a flattened, slightly raised, mesial ridge extending and widening forward from them to the front. Surface marked by fine concentric striæ of growth.

Length of a rather narrow specimen, 0.66 inch; breadth, 0.34 inch.

The specimen represented by our figure is proportionally rather narrower than a majority of those in the collection, and the mesial flattened ridge is not represented tapering enough toward the beak from the front in our figure. It should be narrower, even near the middle of the valve, than the slope on either side. On some specimens, however, it seems to be nearly obsolete, while on others it is quite well defined, and rather distinctly flattened anteriorly, thus imparting a truncated outline to the front. I am not sure that I have seen specimens of *L. melie* from the original locality; but the form here described has been referred to that species by the geologists of the Survey, and was sent to me with that name attached.

Locality and position: Cuyahoga shale, a part of the Waverly group of the Lower Carboniferous, at Johnston, Trumbull county, Ohio. Prof. Hall's type specimens came from Chagrin Falls, Ohio.

LINGULA SCOTICA, Davidson?

Plate 14, fig. 9.

Lingula Scotica, Davidson (1868); Monogr. Scottish Carb. Brach., pl. 5, figs. 36 and 37; British Carb. Brach., p. 207, pl. 48, figs. 27 and 28.

?? *Lingula Scotica*, var. *Nebrascensis*, Meek (1872); Palæont. E. Nebraska, p. 158, pl. 8, figs. 3a, b.

Shell ovoid-subtrigonal, compressed; lateral margins converging with slightly convex outlines from near the front to the beaks, at an angle of about 120°, and rounding to the rounded or faintly subtruncated front;

beak narrow, and apparently rather acutely pointed in well preserved specimens; surface ornamented by distinct concentric lines and furrows.

Length, 1.06 inch; breadth, 0.80 inch.

As I have seen but one mere cast of this shell, I have no means of knowing how far it may vary in form and surface markings, nor of determining whether it is a dorsal or ventral valve, though it is more probably the latter. Although it rather closely resembles Mr. Davidson's species, I am far from being entirely satisfied that it is really the same. It is proportionally narrower than his figure, and has the concentric markings more crowded. The former difference, however, is not greater than often occurs among individuals of the same species, while the latter, as represented in our figure, is a little exaggerated.* It is probably a distinct species, but, without better means of comparison, I do not feel quite willing to separate it. It is even less like the Nebraska Coal Measure form that I have regarded provisionally as a variety of *L. Scotica*, and can hardly belong to the same species as the latter.

Locality and position: Berea grit, Berea, Ohio.

GENUS DISCINA, Lamarek, 1819.

(Hist. Nat., VI., 236.)

SUB GENUS ORBICULOIDEA, D'Orbigny, 1847.

(Compt. Rend., XX., 269.)

DISCINA (ORBICULOIDEA) NEWBERRYI, Hall.

Plate 14, figs. 1a, b, c, d.

Discina Newberryi, Hall (1864); 16th Report of the Regents on the State Cab. Nat. Hist. N. Y., p. 30; and (1867) Palæont. N. Y., IV., 25, pl. 1, figs. 10 and 11.

Shell rather under medium size, circular, or sometimes very slightly oval, the antero-posterior diameter being in the latter cases a little greater than the transverse. Upper valve much depressed, with its apex placed about half way between the middle and the posterior margin, or slightly nearer the latter than the former. Under valve flat, with point of accretion central, and foramen very small, and situated near the margin at the outer end of a deep oval impression extending from the center nearly to the posterior edge. Surface of both valves marked by

*The concentric markings are also too strong on our figure, particularly near the beak, where they make a broad curve.

small concentric striæ, and sometimes also showing very faint traces of radiating markings.

Diameter generally about 0.53 inch in mature specimens.

The radiating markings are so obscure as not to be seen unless carefully looked for in a favorable light, consequently no attempt was made to put them in the drawings, as this could scarcely be done without giving an exaggerated impression in regard to their distinctness. Even the concentric lines are made rather too distinct in fig. 1*a*. The foraminal impression is also a little too narrow and too oblique in fig. 1*d*, where it should extend directly to the center. The specimen from which fig. 1*c* was drawn has the foraminal impression very narrow, sharp, and apparently more like the true slit of a *Discina* proper than like a mere oval impression with a minute perforation at its outer end, as in the group *Orbiculoidea*. Consequently, it may possibly belong to a different shell from that represented by fig. 1*d*.

In regard to the specific affinities of this shell little can be said, as it presents almost no characters at all to distinguish it from several species found in rocks of various ages. I have seen one in our western Coal Measures *very* closely resembling it. Our figure 1*a* shows the concentric striæ coarser than represented by the figures of *D. Newberryi*, given in the Palæontology of New York, but the specimens vary somewhat in that character.

Locality and position: The specimens represented by our figures 1*a*, 1*c*, and 1*d*, are from the Cuyahoga shale, a member of the Waverly group of the Lower Carboniferous, while that represented by fig. 1*b* is in a light-gray, fine-grained, arenaceous matrix, from the same group, at Farmington, Ohio. Prof. Hall's typical specimens were found at Cuyahoga Falls and Akron, Ohio.

DISCINA (ORBICULOIDEA?) PLEURITES, Meek.

Plate 14, figs. 2*a*, *b*.

Shell very nearly circular, or slightly longer than wide. Upper valve much depressed; apex but little elevated, obtuse, and placed very near the posterior margin, with a backward inclination, and more depressed than the surface a little in advance of it; surface only showing fine, obscure, irregular lines, and some stronger wrinkles of growth. Internal cast showing a linear impression along the middle of the anterior slope. Under valve unknown.

Length, 0.93 inch; breadth, 0.89 inch; height a little in advance of apex, 0.16 inch; do. of apex, 0.10.

This species is remarkable for its nearly marginal apex, which is, indeed, placed almost exactly over the posterior margin, though raised about one-tenth of an inch above it. I am not sure whether it is a true *Discina* or not, as I have seen no specimens of the under valve. I suspect that it will prove to be an *Orbiculoidea*, as several of the species described under the name *Discina*, from this horizon, seem to possess the peculiarities of the foramen in the under valve distinguishing the former group. This is certainly the case with *D. Saffordi* of Winchell, and the form I have identified with *D. Newberryi*.

Locality and position: Newark, Ohio. Waverly group of Lower Carboniferous series.

GENUS STROPHOMENA, Rafinesque, 1827.

SUB-GENUS HEMIPRONITES, Pander, 1830.*

(Beitr. zur Geog. de Russ., 74.)

HEMIPRONITES CRENISTRIA, Phillips? (sp.).

Plate 10, figs. 5a, b, c, d.

Spirifer crenistria, Phillips (1836); Geol. Yorkshire, Vol. II., pl. 9, fig. 6.

Spirifer senilis, Phillips; Ib., fig. 5.

Leptæna anomala, J. de C. Sowerby (1840); Min. Conch., tab. 615, fig. 16.

Orthis umbraculum, var. Portlock (1843); Geol. Londonderry, Tyrone, etc., pl. 37, fig. 5:

DeKoninck (1843); Anim. Foss. Terr. Carb. Belg., p. 222, pl. 13, figs. 4-7.

Orthis Bechei, McCoy (1844); Synop. Carb. Foss. Ireland, pl. 22, fig. 3.

Orthis cornata and *O. caduca*, McCoy (1844); Ib., figs. 5 and 6.

? *Orthotetes radians*, Fischer (1850); Bull. Soc., XXIII., pl. 10.

Leptæna crenistria and *L. senilis*, McCoy (1855); Brit. Pal. Foss., pp. 450 and 452.

Streptorhynchus crenistria, Davidson (1860); Monogr. Scottish Carb. Brach., p. 32, pl. 1, figs. 16-22: British Carb. Brach., p. 124, pl. 26, fig. 1, pl. 27, figs. 1-5, and pl. 30, figs. 14-16: Winchell (1862); Proceed. Acad. Nat. Sci., p. 410: and of many other authors.

Shell strongly resupinate, semi-oval, or truncato-sub-circular, being wider than long, with a regularly rounded anterior outline, and lateral

* In accordance with a suggestion in Vol. I., Part II., of the Ohio Geological Reports, I retain here, provisionally, the name *Hemipronites* in a subgeneric sense under *Strophomena*, until the question in regard to the particular group for which the latter name will have to stand has been more satisfactorily settled. Whether certain allied types should be treated as representing distinct genera, or only groups bearing the relations of subgenera of one genus, is often, however, a mere matter of fancy. For the *Hemipronites* group the name *Orthotetes*, Fischer, has been recently retained; but it seems to me that this can scarcely be properly done, for the following reasons:

In the first place, Fischer, in 1829, read a communication from a Mr. Evans before

margins rounding into the front, and usually curving inward behind, so as to intersect the hinge at rather more than right angles; hinge generally a little less than the greatest breadth of the shell. Dorsal valve always distinctly convex over all the central region, and thence rounding downward to the front and lateral margins, while its posterior lateral edges are generally reflected or curved more or less upward; beak rounding over to the hinge, beyond which it projects but little. Ventral valve flattened, or more or less concave, with its lateral, and sometimes its front margins, curved a little upward, and its posterior lateral downward, to conform to the curvature of those of the opposite valve; beak moderately prominent, and directed obliquely backward and upward, but not incurved; cardinal area generally of medium height, flattened, well defined, and inclined a little backward, with its closed triangular fissure varying in its proportional breadth and height with the greater or less elevation of the beak; interior without any mesial septum; muscular impressions occupying a comparatively small, fan-shaped space, that is neither deeply excavated nor bounded by prominent dental ridges. Surface of both valves ornamented by numerous, sub-equal, or alternately larger and smaller, radiating striæ, that increase rather by the intercalation of smaller ones between the larger than by division, the smaller commencing very slender at various distances from the beaks and extending to the free margins, increasing in size, so that they often become nearly or quite as large as the others. Crossing all of these are numerous, very fine, crowded concentric striæ, and obscure, much larger, ridges of growth.

Length of a rather large, wide, adult specimen, 1.73 inches; breadth of do., 2.16 inches; convexity of the two valves at the middle, 0.65 inch; do. of the dorsal valve, measuring from its lateral margins up to the horizon of its most gibbous central region, 0.90 inch.

the Imperial Society of Moscow, containing a description of a new genus which he said was related to *Placuna* and *Pedum*, and proposed to call *Orthotetes*. He neither figured, described, nor cited any example, however, and as it is not possible to know from his description and remarks what genus he had in view, he can not be regarded as having established a genus under that name at that time. It was simply a name resting upon nothing. In 1837, however, Fischer uses the name *Orthotetes*, and figures a shell under it, without a specific name, but having almost certainly the characters of *Hemipronites*. Again, in 1850, Fischer uses the name *Orthotetes*, and figures an example with the name *O. radians* attached, which seems to be *H. crenistria*. But as the genus was thus only properly made known under the name *Orthotetes* in 1837 and 1850, while Pander had described it with illustrative examples in 1830, under the name *Hemipronites*, I think his name should be retained, whether we regard the group as a sub-genus or as a distinct genus.

I have referred this form to Phillips's species, rather because I have been unable to find any constant characters by which it can be separated from some of the European forms referred to the same by high authorities, than from being *entirely* satisfied that a careful comparison of a large series of specimens might not show it to be a closely allied but distinct species. Although varying in form, it does not, so far as I have been able to see, vary in general outline to the extent that *H. crenistria* does in Europe, judging from the published figures, nor have I seen any specimens of it with the area so much elevated, or with the beak of the ventral valve so distorted, as in some foreign examples of that shell. It also usually has its posterior lateral portions more compressed and deflected than *H. crenistria*, as illustrated from British specimens.

I see Mr. Davidson, in his very valuable Monograph of the British Carboniferous Brachiopoda, page 124, cites *Orthis Keokuk* and *O. robusta*, Hall, as synonyms of the European species *H. crenistria*. I can not quite concur with him in this, however, because these, and, I think, all of the several other allied species or varieties found in our Western Carboniferous limestones and Coal Measures differ from the published figures of *H. crenistria*, as well as from the Waverly sandstone specimens under consideration, in having a well-defined, longitudinal mesial septum in the ventral valve, extending from the beak sometimes nearly to the middle of the interior. Mr. Davidson was not acquainted with the interior of Prof. Hall's species, but on examining good specimens of the allied form *H. crassa*, M. and H., from the Coal Measures, sent by me to him some time back, he noticed this internal septum as distinguishing it from the European species *H. crenistria*.

I have, in the Palæontology of the Upper Missouri, published by the Smithsonian Institution, on pages 25 and 26, given my reasons for believing that the rules of nomenclature will compel us to retain Pander's older name, *Hemipronites*, for this group, instead of *Streptorhynchus*, King, whether we regard it as constituting a genus or sub-genus. And in the first volume of the Palæontology of Ohio, page 73, I have stated reasons for believing that when the interior of all of the Carboniferous, Devonian, and Silurian shells of this and allied groups can be thoroughly compared, it will be seen that *Hemipronites* is so closely related to *Strophomena*, Rafinesque, that it can scarcely be separated from the latter more than as a sub-genus. Prof. King's name was proposed for Permian species, with the area and beak of the ventral valve extravagantly elevated, and the beak often much distorted; but when we pass to some of the Carboniferous, Devonian, and particularly to the Silurian species, we find examples with the area nearly or quite as little developed as in some

species of *Strophomena*. Indeed, it is now well known that this character of the elevation of the beak, and the greater or less development of the area can not be, within a considerable range of limits, even relied upon as a specific distinction

Locality and position: The specimens from which our figures and description were prepared were found in the Waverly group of the Lower Carboniferous, in Medina county, Ohio. It also occurs at numerous other localities in this State at the same horizon, and I suspect that some of the Devonian forms that have been described under other names farther eastward may not be specifically distinct. According to some very high authorities, *H. crenistria* occurs both in the Carboniferous and Devonian rocks of Europe. It is certainly a very widely distributed Carboniferous species, its geographical range there being almost coëxtensive with the rocks of that age.

GENUS PRODUCTUS, Sowerby, 1814.

(Min. Conch., I., 153.)

PRODUCTUS (undetermined sp.).

Plate 10, figs. 4a, b, c, d.

At the time the figures of this and the following form were drawn, it was my intention to make a thorough study of the *Producti* and other *Brachiopoda* of the Waverly group, and to prepare full illustrations and descriptions of them all. A failure of health, however, rendered it impossible to carry out this design.

The species here under consideration attains a medium size, has a very gibbous, strongly arcuate, and produced ventral valve, faintly sinuous along the middle, with short ears extending little beyond the lateral margins, and a concave, transversely semi-oval dorsal valve. Its hinge equals about the greatest breadth of the valves, and its surface is armed with small, apparently short spines, that are moderately scattering, and regularly arranged in quincunx, on little tubercles that become more or less elongated on the ventral valve, where they sometimes even assume the character of irregular costæ. These are crossed by very fine, regular, crowded, concentric striæ, and small, generally obscure, concentric wrinkles, that are most regular and best defined over the visceral region of both valves. The costæ are very variable, being sometimes rather distinct, and in other cases quite obscure, or almost entirely obsolete, so that the surface seems nearly smooth between the little tubercles.

It is probably an undescribed species, but the difficulty of distinguishing species in this group is so great, without a good series of specimens and authentic examples of the closely allied species for comparison, that I have concluded not to attempt to decide the question in regard to its

affinities in preparing the text for the press, a part of which I have had to do away from home, and with but few of the necessary facilities at hand. The fact, too, that Prof. Winchell has named and described a number of species of this genus from the same formation, none of which have yet been figured, renders it still more difficult to arrive at satisfactory conclusions whether our specimens belong to a new species or not.

Locality and position: Sciotoville, and various other localities in the Waverly group of the Lower Carboniferous series in Ohio. I think I have also seen the same shell in beds of the same age (Choteau limestone) in Missouri, and the Kinderhook group of Illinois.

PRODUCTUS (undetermined sp.).

Plate 10, fig. 3.

This is a larger, wider, and less produced form than the last, with much more distinct longitudinal costæ. It much more nearly resembles *P. semireticulatus* than the last, but has the concentric wrinkles decidedly smaller and less distinct over the visceral region, and doubtless differs in other respects from that species. The costæ of the species described above are so exceedingly variable that I am not altogether *clearly* satisfied that it may not be connected with this by specimens presenting intermediate characters, though I think it is not.

Locality and position: Same as last.

GENUS ATHYRIS, McCoy, 1844.

(Synop. Carb. Foss. Ireland, 128.)

ATHYRIS LAMELLOSA, Leveillé? (sp.).

Plate 14, figs. 6a, b.

Spirifer lamellosus, Léveillé (1835); Mem. Geol. Soc. France, II., 39, figs. 21-23.

Spirifer squamosus, Phillips (1836); Geol. Yorks., II., 220, pl. 10, fig. 21.

Terebratulula lamellosa, DeKoninck (1843); An. Foss. Belg., 299, pl. 20, figs. 5a, b, c.

Compare *Spirigera Hannibalensis*, Swallow (1860); Trans. St. Louis Acad. Sci., I., 649: also *Athyris crassiscardinalis*, White (1860); Boston Jour. Nat. Hist., VII., 229.

Shell transversely sub-elliptic, being usually about two-thirds as long as wide, moderately convex; hinge line long, and often nearly or quite straight, but rounding off at the lateral extremities, and never equaling the breadth of the valves; lateral margins rather narrowly rounded; front more or less rounded, or forming a transversely semi-elliptic curve in general outline, but usually produced and sub-angular in the middle, at the termination of the mesial fold and sinus. Dorsal valve a little more convex than the other, its greatest convexity being in the central

region, in front of which it rises into a low, rounded, mesial fold, that is rarely continued very obscurely visible to the umbonal region, with sometimes the faintest possible tendency to become flattened on top; beak very short and incurved. Ventral valve having a more flattened appearance, especially anteriorly, where it is impressed into a shallow mesial sinus, which narrows rapidly backward, and is sometimes continued faintly to the umbonal region; beak a little ventricose, but only projecting slightly beyond that of the other valve, upon which it is closely incurved. Surface of each valve provided with about eight or ten strongly projecting, and sometimes slightly waved, concentric lamellæ, which rise abruptly from the surface, excepting around the front and lateral margins, where they are more crowded, and extend out horizontally to considerable distances; very fine concentric striæ, and sometimes obscure traces of radiating markings, are also seen between and upon the lamellæ.

Length of a rather transverse, mature specimen, exclusive of the extended lamellæ, 1.05 inches; breadth of do., 1.59 inches; convexity, 0.60 inch.

Internal casts of the ventral valve of this shell show that the impressions of its divaricator muscles are faintly marked, and, together, occupy a comparatively large, somewhat fan-shaped space, extending forward beyond the middle of the valve, while those of the adductor muscles extend about half the length of the divaricators between the upper ends of the latter, and, as joined together, present a neat cordate outline, very pointed below. Casts of the rostral cavity show it to be tapering, arched, rounded, or a little flattened on top, and transversely striated, while on each side of it the umbonal region shows a few granules, representing minute pits in the interior of the valve. On casts of the interior of the dorsal valve impressions of the quadruple muscles are usually well defined, the upper pair being each rhombic, connected along the straight inner edges, and sometimes unequally bilobed above, while the lower pair are longer, and occupy a somewhat larger and obovate space, that tapers below, and is a little obliquely truncated on each side above. The cast of the rostral cavity is small, much arched, and rapidly tapering to a point that looks as if it had filled a minute perforation in the point of the beak. The internal mesial ridge is very small, or merely sharply linear, and extends forward sometimes to the middle of the valve, and backward to the point of the rostral cavity. The perforation of the ventral beak seems to be small, judging from the cast of the rostral cavity.

I have not had an opportunity to compare specimens of this shell with

Prof. Swallow's types of his *Spirigera Hannibalensis*, but believe it to be the same form described by him. In regard to its relations to *Athyris lamellosa*, I can only say that a comparison of our specimens with Mr. Davidson's figures of that species shows no constant differences, though it varies much in form, and while some specimens agree quite nearly with *A. lamellosa*, others seem to have a shorter and more obtuse ventral beak than those figured by Mr. Davidson. It should also be explained here that the specimen represented by our figure on plate 14 is rather more than usually transverse, and has a longer and straighter hinge than the others. The latter character, however, is more marked than natural, in consequence of the fact that the specimen is merely an internal cast, the thick shell of the rostral region, when present, causing the hinge margin to appear shorter.

This shell seems also to be nearly related to *Athyris crassicaudalis*, White, described from near the same horizon at Burlington, Iowa, and may be the same. I regret having no opportunity to make the necessary comparisons with Prof. Swallow's and Dr. White's types, to be able to arrive at more satisfactory conclusions in regard to their relations to the form under consideration. I had expected to do this before preparing the description, and had also intended to give here much more full and complete illustrations of this and the other Waverly *Brachiopoda*, but, as elsewhere explained, a failure of health rendered this impossible, and made it necessary merely to arrange on the plates such of the figures as were already drawn at the time they were called for.

Locality and position: Sciotoville, Ohio. In the Waverly group of the Lower Carboniferous.

GENUS SPIRIFER, Sowerby, 1815.

(Min. Conch., II., 42.)

SPIRIFER CARTERI, Hall.

Plate 14, figs. 7a, b, c, (d?)

Spirifer Carteri, Hall (1857); Regents' 10th Ann. Rept. on State Cab. Nat. Hist. N. Y., 170.

Spirifer (*Cyrtia*?) *Hannibalensis*, Swallow (1860); Trans. St. Louis Acad. Sci., I., 647.

Compare *Spirifer textus*, Hall (1857); Regents' 10th State Cab. N. H. Report, 169; also *Spirifer capax*, Hall (1858); Iowa Geological Report, p. 520, pl. 7, figs. 7a, b: *Syringothyris typus* and *S. Halli*, Winchell (1863); Proceed. Acad. Nat. Sci., Philad., pp. 7 and 8: and *Spirifer cuspidatus*, Martin (sp.), as illustrated in Mr. Davidson's Monogr. Brit. Carb. Brach., pls. 8 and 9.

Shell attaining a rather large size, very thin, nearly semicircular, as seen in a direct view from above or below, and rhombic-subquadrangular in a front or posterior view, with length generally a little more than half

the breadth, and the breadth usually about twice the height of the area; hinge line about equaling the greatest breadth; front and lateral margins forming together a more or less nearly semicircular curve, or with the central part of the former sometimes a little straightened, or even very faintly sinuous in outline, and the latter meeting the hinge at rather less than right angles behind. Dorsal valve moderately convex in the central region, thence sloping laterally, and rounding more abruptly to the beak and anterior lateral margins than to the middle of the front; mesial fold depressed, smoothly rounded, equaling about two-thirds the breadth of the valves at the front, and sometimes showing on internal casts a faint linear mesial impression; beak small, and with the very narrow area incurved. Ventral valve much elevated at the beak, thence sloping laterally, with slightly convex outlines, at an angle of 100° to 125° , and more abruptly to the front and anterior lateral margins; mesial sinus smoothly rounded within, rather shallow, or moderately deep anteriorly, where it terminates in a short rounded projection fitting into a corresponding sinus in the margin of the other valve; beak elevated, obtusely angular and straight, or a little arched backwards; area high, transversely and vertically striated, ranging more or less nearly at right angles to the plane of the valves, and flattened or somewhat arched backward, with its lateral margins moderately well defined; foramen large, or about two-sevenths as wide at the hinge line as the length of the latter, and three-fifths as wide as high, showing its deep-seated transverse septum and tube to be well developed above within.

Surface of both valves ornamented on each side of the non-costate mesial fold and sinus by about eighteen to twenty simple, depressed, rounded, radiating costæ, some five or six of which, on each of the lateral extremities of both valves, are usually nearly or quite obsolete.* Crossing all of these, on well-preserved specimens, numerous fine concentric striae and some stronger marks of growth may be seen; and over the whole a minute pitting may be observed, so crowded and arranged as to present a delicate textile appearance, as seen by the aid of a magnifier.

Breadth of a well-developed, mature specimen, 2.70 inches; length, about 1.37 inches; length of hinge line, 2.65 inches; height of area, 1.25 inches; breadth of foramen at hinge, about 0.73 inch.

This shell seems to agree almost as well with *Spirifer textus*, Hall, from the fine-grained (Carboniferous) sandstone of the Knobs, near Louis-

* The costæ are too sharply defined, and represented too small and too numerous on the ventral valve in our figures 7a and 7b. They are about right on the dorsal valve in fig. 7a; but the lateral slopes of the ventral valve in the same figure are incorrectly drawn straight, instead of somewhat convex, thus making the lateral extremities of the figure too acutely angular.

ville, Kentucky, as with *S. Carteri*, originally described from the Waverly group of Ohio. Its area is proportionally somewhat larger, flatter, and less arched, as well as more distinctly defined, than it appears to have been in the typical specimens of *S. Carteri*; but the margins of its area are still less sharply defined, and the lateral slopes of its ventral valve less flattened, and less abruptly inclined forward, than in the type for which the name *S. textus* was proposed. These, however, are usually such variable characters in shells of this kind that we may generally question the propriety of viewing them as specific differences, unless accompanied by some more constant and reliable distinguishing features.

The shell for which Prof. Swallow proposed the name *Spirifer* (*Cyrtia*?) *Hannibalensis* seems to agree in its specific characters with the Ohio form under consideration; and I even suspect that *Spirifer capax*, Hall, and *Syringothyris typus* and *S. Halli*, of Winchell, may possibly be varieties of the same species. It is true I have not seen specimens of the Ohio shell in a condition to show whether or not it possess the punctate structure seen in Prof. Winchell's types, as well as in most of the others already mentioned, but it certainly has the same deep-seated septum and internal tube as *Syringothyris* (see markings in cast at + of fig. 7c); and from this fact, and all of its other characters, it may be regarded as almost morally certain that it has the same shell structure.

Again, it will be observed that all of these shells bear very close relations to the various forms or varieties referred by the highest European authorities to the common and widely distributed *Spirifer cuspidatus*, Martin. None of the specimens of the Ohio shell under consideration that I have seen have the area and beak of the ventral valve so extravagantly elevated as some of those of *S. cuspidatus* figured by Mr. Davidson and others; but this is a variable character, some of the figures of the European shell not differing materially from ours in this respect.* I have not seen any examples of internal casts of *S. cuspidatus*; but if the specimen represented by our figure 7d really belongs to the species under consideration (of which there may be some doubts), it would seem not to agree very well with Mr. Davidson's description of the interior of the corresponding valve of *S. cuspidatus*.

The only characters mentioned by Prof. Hall as distinguishing his *S. textus* from *S. cuspidatus* were the supposed greater number of costæ, and the peculiar minutely pitted or textile appearance of the surface in the former. But he described both his *S. textus* and *S. Carteri* as having only from eighteen or nineteen to twenty costæ or plications on each side of the mesial fold and sinus, while Mr. Davidson gives thirty to forty-four

Mr. Davidson mentions that there are all gradations from specimens with a comparatively low area to the typical forms of *S. cuspidatus*.

as the number on each valve of *S. cuspidatus*, which would make from fifteen to as many as twenty-two on each side of the fold and sinus. It is true that the published figures or descriptions of *S. cuspidatus* do not generally show or mention the minute textile markings seen on well-preserved specimens of these American shells, but Prof. King has noticed something of the kind on that shell,* and I believe I have seen unmistakable traces of them on a European specimen agreeing exactly with *S. cuspidatus* in form, and sent to this country with that name attached. I also found the punctate structure plainly visible in this shell.†

Locality and position: Prof. Hall's typical specimens of *S. Carteri* came from the Waverly group in Licking county, Ohio, and the specimens figured on our plate came from the same horizon at Sciotoville, Ohio. The same form almost certainly occurs in the equivalent beds of Michigan and Illinois, while Prof. Swallow's *Spirifer* (*Cyrtia*) *Hannibalensis*, which is almost certainly the same species, came from about the equivalent horizon at Hannibal, Missouri.

* See Geol. Mag., Vol. IV., No. 6, 1867.

† In making the first announcement of the discovery of the punctate structure, and its coincidence with the internal characters of the proposed genus *Syringothyris*, in shells of this character, I ventured the prediction that this structure really exists in the types of *Syringothyris*, which had been supposed not to be punctate, and suggested that at least some of the British forms referred to *Spirifer cuspidatus* would yet be found to possess the internal characters of *Syringothyris*, along with a punctate shell structure. (See Proceed. Acad. Nat. Sci., Philad., for December, 1865, p. 275.) Soon after the publication of these facts and suggestions, I had, through the politeness of Prof. Winchell, an opportunity to examine his type specimens of *Syringothyris*, and found them, as predicted, to be really punctate shells. At a somewhat later date Dr. Carpenter, the distinguished microscopist of London, examined a number of British specimens agreeing in all external characters with *S. cuspidatus*, and found some of them, as predicted, to possess the internal characters and punctate structure of *Syringothyris*, while in others he found neither the internal tube of *Syringothyris* nor the punctate structure. Prof. King, of Belfast, however, at a still later date, examined many British specimens of these shells, and arrived at the conclusion that, when well preserved, they are all both provided with the internal tube and punctate structure, and also all belonging to the one species *Spirifer cuspidatus*. He, therefore, accounts for the absence of the internal tube and punctate structure in some of the specimens examined by Dr. Carpenter by the accidental removal of the former, and the destruction of the latter during the process of fossilization, as certainly did take place in many punctate fossil shells. Consequently, he adopts *Syringothyris* as a distinct genus from *Spirifer*, and regards Prof. Winchell's *S. typus* as specifically identical with *Spirifer cuspidatus*, Sowerby. Although rather inclined to think he may be right in the latter conclusion, I can not agree with him in making *Syringothyris* distinct from *Spirifer*, Sowerby, because it seems to me, as stated in the Palæontology of the Upper Missouri, page 18, that the rules of nomenclature will compel us to regard *S. cuspidatus* as the type of the genus *Spirifer*, Sowerby, and, consequently, to place *Syringothyris* as a synonym of the latter.

WAVERLY GROUP SPECIES.

SUB-GENUS TRIGONOTRETA, King, 1825.

SPIRIFER (TRIGONOTRETA) STRIATIFORMIS, Meek.

Plate 14, figs. 8a, b, c, d, e.

Shell attaining a full medium size, moderately gibbous, semi-oval, or sub-trigonal in outline; hinge nearly or quite equaling the greatest breadth; anterior margin more or less rounded, or sometimes a little projecting or subangular at the middle; lateral margins rounding to the front, or sometimes converging forward, with somewhat straightened outlines, and meeting the hinge behind generally at about right angles. Ventral valve more convex than the other, its greatest convexity being near or a little behind the central region, from which it rounds over a little more abruptly to the beak than to the front and anterior lateral margins; beak rather pointed, moderately prominent, and strongly incurved; cardinal area of medium size, well defined, and more or less arched and inclined backward; foramen about one-fourth to one-fifth as wide as the hinge, and apparently always wider than high; mesial sinus narrow, rather deep anteriorly, and continued much attenuated usually to the beak; interior (as shown by internal casts) with dental laminae short and diverging, and rostral cavity comparatively rather small, of moderate depth, strongly striated longitudinally, and marked by a few diverging ridges parallel to its anterior lateral margins, while the bottom of the valve on each side, in the umbonal region, is usually occupied by numerous small pits. Dorsal valve depressed convex, or sometimes rather prominent at the middle anteriorly, and rounding abruptly to the beak, and less strongly rounded or sloping to the anterior lateral margins; beak projecting little beyond the hinge, and, with the very narrow area, distinctly incurved; mesial fold narrow, rising very little above the general convexity in the umbonal region, and continued rounded, without distinctly defined margins, either much depressed or moderately elevated, to the front, where it is sometimes prominent enough to give origin to a semicircular sinus in the edge, to receive a corresponding short projection of the margin of the other valve. Surface of both valves (including sinus and fold) ornamented by numerous, rather small, depressed, rounded, more or less bifurcating, longitudinal costæ, crossed toward the front and lateral margins by distinct, sub-imbriating marks of growth, while over the whole, well-preserved specimens show a very beautiful, minute, cancellated sculpturing, formed by numerous, very sharply defined, and crowded radiating and concentric striæ.

Length of a medium sized, mature specimen, 1.50 inches; breadth, 1.90 inches; convexity, about 1 inch.

This species has much the general external appearance of *Spirifer Mosquensis* of Fischer, as illustrated by Mr. Davidson from British specimens, though its marks of growth show that the young shell was proportionally wider, and its lateral angles more acute, than any of Mr. Davidson's figures would indicate, while neither he, MM. DeVerneuil, DeKoninck, nor any of the other authors who have figured and described that shell, so far as I have seen, either mention or illustrate the beautiful fine cancellated sculpturing seen on the species under consideration. The most marked and decided difference, however, at least from the original typical Russian examples of *S. Mosquensis*, is the very much greater development and anterior extension of the dental laminæ of the latter species.

It also resembles, though less nearly, the common *S. striatus* of Sowerby, but may be readily distinguished by its proportionally less transverse and more gibbous form, as well as by its less acute lateral angles, than we generally see in that species, while its rostral cavity has a different form. The minute cancellated sculpturing of its surface is also more delicate than that of *S. striatus*, var. *clathratus* (as illustrated by Mr. Davidson), which is the only European form referred to *S. striatus* on which markings of that nature have yet been illustrated by any of the authors I have had an opportunity to consult.

Prof. Swallow has described several species that seem to be more or less similar to this, from about the same horizon in Missouri, with which forms it ought to be compared. I have no authentic examples of these Missouri shells for comparison, however, but so far as can be determined from the published descriptions, none of them seem to agree exactly with this shell.

Locality and position: Waverly group of the Lower Carboniferous at Sciotoville and many other localities in Ohio.

SPIRIFER (TRIGONOTRETA) BIPLICATUS, Hall??

Plate 14, fig. 5.

Spirifer biplicatus, Hall (1858); Iowa Geological Report, I., part Palæont., 519.

Compare *Spirifer Osagensis*, Swallow (1860); Trans. St. Louis Acad. Sci., I., 641.

Shell rather under medium size, trigonal-subsemicircular, with breadth twice to twice and a half the length, moderately convex; hinge line much longer than the breadth of the valves at any other point, and

sometimes abruptly produced in the form of slender, long, very sharp, spine-like extensions; lateral margins converging, with more or less convex outlines forward to the front, which is narrowly rounded or sub-angular at the middle. Dorsal valve depressed convex in the central region, and compressed near the posterior lateral angles; beak projecting little beyond the hinge line, and, with the narrow area, rather strongly incurved; mesial fold narrow, rounded, and depressed, or scarcely rising above the general convexity of the central and umbonal regions, but usually becoming somewhat more elevated at the front, defined on each side by a little larger and deeper furrow than those between the larger costæ. Ventral valve of nearly the same general form as the other; mesial sinus moderate, and narrowly extended to the beak; area rather narrow; beak moderately prominent and incurved. Surface of each valve ornamented by about thirty to thirty-six rather small radiating costæ, some six to eight of which usually occupy the mesial fold at the front in mature specimens, and five to seven the mesial sinus, those of the fold and sinus, as well as one or two of the larger ones on each side, bifurcating, while the others are generally all simple; crossing the whole, numerous fine concentric striæ and an occasional stronger mark of growth may be seen on well-preserved specimens.

Greatest breadth of a mature specimen with lateral extremities produced as mucronate extensions (measuring to the points of the latter), 1.75 inches; do., exclusive of the spines, 1.20 inches; length, 0.59 inch.

The lateral extremities of this shell seems to be always acutely angular, and often mucronate; but the individual figured has them *unusually* produced and pointed, as well as remarkably abruptly projecting from the posterior lateral margins, which generally curve outward a little into the bases of the spines, instead of meeting them at obtuse angles.* The costæ on the mesial fold usually commence at or very near the beak, as two very small, obscure divisions, which soon bifurcate so as to form four, the lateral two of which subdivide at some point farther forward, and sometimes the middle two bifurcate toward the front so as to make eight altogether. The furrow between the middle two costæ of the mesial fold, as well as those between the lateral margins of the fold and the costæ on each side, are usually a little larger and deeper than the others. This character, and the bifurcations of the costæ on the fold, and one or two of the lateral ones on each, are not well shown in our figure.

Although I believe this to be the species described by Prof. Hall under

* This angularity at the connection of the posterior lateral spines and the lateral margins, however, is slightly exaggerated in figure 5.

the name *S. biplicatus*, the identification has not been made from direct comparison with authentic specimens of that shell. I also think it very possible that *S. Osagensis*, Swallow, is only a more gibbous form of this shell, with less extended lateral angles. At any rate, there are specimens among the Ohio collections agreeing pretty nearly with the description of *S. Osagensis*, that seem to be connected with the form figured on our plate by intermediate varieties. I much regret that the circumstances elsewhere explained prevented me from giving full illustrations of both valves, as well as of the different varieties of this shell.

Locality and position: Upper members of the Waverly group, at Richfield, Ohio. rs at the same horizon in Iowa, and probably in Missouri and Illinois.

LAMELLIBRANCHIATA.

GENUS ENTOLIUM, Meek.

(Cal. Geol. Rept., II., 479.)

ENTOLIUM SHUMARDIANUM, Winchell? (sp.)

Plate 15, figs. 4a, b.

Pernopecten Shumardianus, Winchell (1865); Proceed. Acad. Nat. Sci., Philad., XVII., 126.

Compare *P. limatus*, Winchell (1865), Ib., and *Avicula Cooperensis*, Shumard (1855), Missouri Geol. Report.

Shell compressed-lenticular, thin, nearly equivalve, suborbicular exclusive of the ears; basal margin rounded; lateral margins rounded or with the posterior one sometimes slightly truncated or straightened on the upper slope, both apparently a little gaping above the middle; umbonal slopes straight and converging to the beaks at an angle of about 115°; hinge margin very short, or scarcely equaling two-fifths of the greatest breadth of the valves below, in the left valve sloping very slightly inward from the extremities of the ears to the beak at the middle, but in the right valve straight; ears small, flat, triangular, equal, or very nearly so, and obtusely angular at the extremities, without any traces of a byssal sinus under them on either side;* beaks small, equal,

*The ears are not represented quite obtuse enough in our figure 4a. If their lateral margins were continued up from below *straight* (but obliquely), so as to intersect the hinge margin above at an angle of about 100°, instead of being a little sinuous, they would be correct. The same objection also applies, though in a less marked degree, to figure 4b.

WAVERLY GROUP SPECIES.

compressed, and not projecting above the hinge margin or showing the slightest obliquity; superior lateral regions compressed and separated from the more convex central portion by shallow undefined impressions that diverge from each side of the beaks at an angle of about 90° , the one on the posterior side being usually longer than the other. Surface appearing nearly smooth, but showing under a magnifier very fine, regular, crowded, and obscure concentric striae, with a few finely marked, irregular furrows of growth, and sometimes the slightest possible traces of radiating striae, that are generally entirely obsolete.

Height, 1.04 inches; breadth, 1.08 inches.

The foregoing description was mainly drawn up from the specimen represented by our figure 4a. This I believe to be a left valve. Other specimens in the collection, however, present the form shown by our figure 4b. These are believed to be the right valve of the same species, and will be seen to have the hinge line straight, and the superior lateral margins more protuberant in outline, so as to give a different form to the whole valve. I have observed precisely the same differences between what we have every reason to believe to be the opposite valves of a scarcely distinguishable species found in the Coal Measures, as may be seen by figures given on plate 9 of *Palæontology of Eastern Nebraska*, published in Hayden's Nebraska Report of 1872, and on plate 26 of the fifth volume of the *Illinois Geological Reports*.

I am in considerable doubt in regard to the specific name that ought to be retained for this shell. It perhaps agrees most nearly with Prof. Winchell's description of his *Pernopecten Shumardianus*. But after seeing how these shells vary in the slight details of form and their obscure surface markings, it seems to me quite as probable that it may belong to his *P. limatus*, or rather that the latter and *P. Shumardianus* may both belong to one species, also including our shell. Prof. Winchell did not see the hinge in either of these forms, but merely referred them to his genus *Pernopecten* from their general external resemblance to the type of that group. I feel well assured, however, that at least the specimens here under consideration have not the crenate hinge characterizing *Pernopecten*, and can not be properly referred to that group.

Again, it certainly bears very close relations to *Avicula Cooperensis*, Shumard, from rocks of the same age in Missouri. In making comparisons with the latter, however, it should be kept in mind that the figure of Shumard's species, given in the Missouri report, was drawn from a very aberrant specimen, which also had its ears partly hidden by the rock, so as to cause a misapprehension in regard to their form. The

radiating costæ seen on Shumard's figure, as I have elsewhere explained, are also made *much* too strong by the engraver, even for the individual specimen there represented, while in a great majority of specimens *no traces of them whatever are to be seen*. In looking over a large collection of specimens of *P. Cooperensis*, sent by Dr. Williams, of Booneville, Missouri, to the Smithsonian Institution, from the same locality and bed from which Dr. Shumard's original typical specimens were obtained, I could only discover faint traces of radiating costæ on two or three of them, while all of the others were as completely destitute of any such costæ as the specimen from which our figure 4a was drawn.

At one time I strongly suspected that *Aviculopecten limiformis* of White and Whitfield, the type of *Pernopecten*, Winchell, might also be the same species as *Avicula Cooperensis*, Shumard; but on examining the specimens of the latter mentioned above, I was unable to discover any traces whatever, in any of them, of the crenate character of the hinge seen in the type of *Pernopecten*.

Some years back, Prof. Winchell did me the favor to loan me the type specimens of his genus *Pernopecten*, and I made careful drawings of two of them, one of which shows the crenate character of its hinge very clearly, while the other gives as satisfactory a view of the exterior. They are both, I think, right valves, and the one showing the hinge agrees almost *exactly*, in all *specific* characters, with the form represented by our figure 4b, though it is proportionally not quite so broad, and has slightly more obtuse ears, while the other agrees even more closely in form with our figure 4a, excepting in having its hinge straight, which, I think, is due to the fact of it being a right valve. Again, Prof. Winchell's type actually seems to agree exactly, in all constant *specific* characters, with *Entolium aviculatum* (= *Pecten aviculatus*, Swallow), already mentioned, from the Coal Measures. So we have here a remarkable case of shells presenting extremely little or *no* constant *specific* difference, and yet differing in a character of the hinge that seems to be of *generic* importance.

Locality and position: The specimen from which our figure 4a was drawn came from the Cuyahoga shale of the Waverly group at Richmond, Ohio, and that represented by figure 4b came from the Waverly group at Lodi, Ohio. Prof. Winchell's type specimens of *E. Shumardianus* and *E. limatus* came from the yellow arenaceous beds at Burlington, Iowa, and I believe he has identified the same forms at this horizon in Michigan.

GENUS AVICULOPECTEN, McCoy, 1851.

(An. and Mag. N. H., VII., 171.)

AVICULOPECTEN CRENISTRIATUS, Meek.

Plate 15, figs. 7a, b.

Aviculopecten crenistria, Meek (1871); Proceed. Acad. Nat. Sci., Philad., XXIII., 4.

Shell thin, attaining a moderately large size, plano-convex, with a truncato-suborbicular outline; height and breadth nearly equal; basal margin more or less regularly rounded; posterior margin rounding from the posterior ear into the base, sometimes a little straightened above; anterior side rounded so as to make a shorter curve than the other; hinge less than the breadth of the valves in length, but rather long. Left valve moderately convex; beak rising a little above the hinge margin, nearly or quite central, and not oblique; posterior ear small, with a marginal ridge, flat, without being separated from the swell of the umbo by a sulcus, rather acutely angular at the extremity, and distinctly shorter than the margin below, from which it is separated by a nearly rectangular notch; anterior ear larger, or sometimes nearly as long as the margin below, rather acutely angular at the extremity, convex, and separated by a rounded impression from the umbo, defined by a rather deep subangular marginal sinus. Surface ornamented by numerous, very slender, radiating costæ or raised lines, separated by rather wide, flat spaces, in each of which a still smaller line is sometimes intercalated; crossing all of these are smaller, regularly arranged, sharply elevated, concentric lines, that seem to form little projections at the points of crossing, so as to give a rough appearance to the surface; costæ becoming more closely crowded, but not smaller on the ears. Right valve flat or a little concave, with beak obsolete; ears flat, and of nearly the same size and form as in the other valve, excepting that the anterior one is broader and defined by a more shallow and more rounded sinus than appears to exist in the left valve; surface cancellated by regular, rather closely arranged, radiating and concentric lines, the latter being very sharply elevated, and minutely and regularly waved, crenate, or somewhat vaulted; radiating costæ somewhat larger and more distant on the ears.

Height, 2.50 inches; breadth, 2.78 inches; convexity, 0.40 inch.

The specimens of this species are not very well preserved, being mainly casts with some portions of the surface. It is rather remarkable in having only a comparatively shallow rounded sinus under the an-

terior ear of the flat right valve, where it is usually deep and angular in species of this genus, while in the left it is deeper and more angular, though none of the specimens are in a condition to show clearly its exact form. One cast shows a little of the cardinal plate, which is rather coarsely striated longitudinally. None of the specimens of the left valve have the surface well enough preserved to show whether the sharply elevated concentric lines or laminae are minutely waved, as in the other valve, but they probably are so when the surface has not been worn or exfoliated.

I am not acquainted with any described species so nearly allied to this as to render a comparison necessary.

Locality and position: Sciotoville, Ohio. Upper part of the Waverly series of the Lower Carboniferous.

AVICULOPECTEN WINCHELLI, Meek.

Plate 15, figs. 5a and 5b?

Shell attaining about a medium size; left valve compressed convex, exclusive of the ears, presenting a slightly oblique, irregularly subtrigonal or subcircular outline; hinge equaling two-thirds to three-fourths the greatest breadth below; basal outline forming a more or less oblique semicircular curve; posterior margin most prominent near the middle, where it is usually subangular, and thence rounding into the base below, while above it is straightened or even slightly concave in outline obliquely forward and upward into the sinus under the ear; anterior margin most prominent above the middle, where it is somewhat abruptly rounded, and thence descending and curving nearly vertically into the base, and rounding, with a slightly straightened outline, obliquely upward and backward into the sinus above; ears subequal, or with the posterior one about one-fourth larger than the other, both abruptly flattened from the umbonal slopes, triangular in form, and shorter than the margins below, the posterior one being generally rather acutely angular, and defined by a deep, wide, rounded or subangular sinus, while the anterior is a little more obtuse than the other, and defined by a somewhat narrower and more angular sinus; beak rather compressed, abruptly pointed, with apex subcentral, and extending to, or very slightly above, the hinge margin. Surface of both disc and ears ornamented by numerous small radiating linear costae or raised striae, about every third, fourth, or fifth one of which is usually slightly larger than others, the smaller

ones generally dying out at various distances between the free margins and the beak; crossing all of these radiating costæ, numerous, much finer, more crowded, and more regular concentric striæ, and a few very obscure ridges and furrows of growth, may be seen.

Breadth of largest specimen of this valve seen, 1.88 inches; height, 1.53 inches; convexity, about 0.24 inch; length of hinge, 1.10 inches.

The foregoing description and measurements are, as stated, made out entirely from left valves. There are, however, in the collection, from the same beds and locality, casts of some smaller right valves, that almost certainly belong to the same species. (See fig. 5b.) These are very nearly, or, sometimes, quite flat, have the ears proportionally larger, so as to make the hinge line as long as the breadth of the disc below, while the sinuses under their ears are deeper and narrower (particularly the anterior one*) than in the other valve. They also differ in having the flattened disc smooth, or only showing minute, crowded, concentric striæ, with sometimes very faint traces of radiating lines. On the ears, however, this valve has the radiating costæ nearly or quite as strong as those of the other valve.

The specimens of the left valve vary somewhat in form, some of the smaller being proportionally narrower across the disc, and having the ears more nearly equal (the anterior one being also more acutely angular) than that represented by our figure 5a. In other large specimens, however, the proportional breadth is even somewhat greater than in that we have figured.

This species has *very* nearly the outline and surface markings of *A. Coxanus*, Meek and Worthen, from the Coal Measures of Illinois and Nebraska.† The right valve of the *A. Coxanus* is unknown, but its left valve is so nearly like that of certain varieties of the form under consideration, that there is little, excepting the much larger size and more robust appearance of the Waverly shell, by which the two can be distinguished. Yet I have no doubts in regard to their belonging to distinct species, not only from the great difference of size, but also on account of the rather widely separated horizons at which they occur, the species of this type of lamellibranchiate shells being usually more restricted in their vertical range. In size, it agrees more nearly with *Aviculopecten rectilaterarius*, Cox; but it differs from that species in having a deep

* This anterior sinus is not represented quite angular enough in our figure 5b.

† See Palæontology Eastern Nebraska, published in Hayden's Nebraska Report of 1872, pl. 9, fig. 2a.

sinus under the posterior ear, as well as in some of its less important details.

Locality and position: The specimens figured on our plate are from the Waverly group of the Lower Carboniferous, at Newark, Ohio. Through the politeness of Prof. A. Winchell, I was permitted to make tracings for comparison from drawings he has prepared of this shell from the same horizon in Michigan.

GENUS PALÆONEILO, Hall, 1870 ?

(Prelim. Notice Lamellib. Upper Held., etc., 6.*)

PALÆONEILO BEDFORDENSIS, Meek.

Plate 15, figs. 3a, -b, c.

Shell subovate, compressed, or moderately convex, height more than three-fourths the length, the highest point being in front of the middle; basal margin semiovate, most prominent antero-centrally, from near which it ascends with a slightly straightened, oblique outline behind, and rounds up oblique to the front; posterior margin narrowly rounded, and somewhat compressed; anterior side shorter and more broadly rounded; dorsal margin arcuate, declining more abruptly in front of the beaks, which are moderately prominent, and situated a little more than one-third the length of the valves from the anterior margin. Surface ornamented by very fine, regular, closely arranged concentric striae, that become obsolete on the posterior third of the valves. Oblique posterior sulcus very faintly indicated, or entirely wanting.

Length, 0.57 inch; height, 0.42 inch; convexity, about 0.14 inch.

This species seems to be most nearly allied to *P. brevis*, from the New York Chemung, but differs in not being "very ventricose," and in having its lines of growth very regular, instead of "irregular." Like that species, its oblique posterior sulcus or constriction is quite nearly obsolete. I have not seen its hinge clearly enough to be *entirely* sure that it belongs to the group *Palæoneilo*; but from its crenate hinge margin, and general form, it probably belongs to that genus.

Locality and position: Bedford, Ohio. Bedford shale of the Waverly group.

* I cite this paper here and elsewhere, with the above date, not because I *know* it to have been properly *published* at the time, but because I have heard of a few copies being sent out during the year 1870, one of which I have seen. Neither this copy, nor, so far as I can learn, any of the others, had any title page or author's name attached; but it has been attributed to Prof. Hall in a notice published in the *American Journal of Science and Arts*.

GENUS SCHIZODUS, King, 1844.*

(Ann. and Mag. Nat. Hist., XIV., 313.)

SCHIZODUS MEDINAENSIS, Meek.

Plate 15, figs. 1a, b, c.

Schizodus Medinaensis, Meek (1871); Proceed. Acad. Nat. Sci., Philad., XXIII., 165.

Shell of medium size, subtrigonal, moderately convex above the middle and cuneate below, somewhat longer than high; anterior side rounded; basal margin somewhat straightened or slightly convex in outline along the middle, rounded up regularly in front and more abruptly behind; dorsal outline sloping nearly at right angles from the beaks toward the extremities, the anterior slope being more abrupt than the other; posterior side longer than the anterior, sloping with a more or less convex or subtruncate outline above, and very narrowly rounded at the extremity below; beaks rather prominent, abruptly pointed, located a little in advance of the middle; posterior umbonal slopes rather prominently rounded or subangular from the beaks obliquely to the posterior basal extremity. Surface nearly smooth, or only showing fine lines of growth.

Length, 1 inch; height, 0.82 inch; convexity, 0.44 inch.

This species has been supposed to be identical with, or nearly related to, a New York Chemung form, which was, I believe, described by Mr. Conrad under the name *Nuculites Chemungensis*. It certainly differs, however, materially in form from that shell as figured and described by Mr. Conrad in Vol. VIII. of the Journ. Acad. Nat. Sci., Philad., and might with about as much propriety be identified with Western Coal Measure species, ranging even up into beds referred by some to the Permian. One of these, described by Prof. Swallow under the name *Cypriocardia? Wheeleri* (Trans. St. Louis Acad. Sci., Vol. II., p. 96, 1862), and figured by Prof. Geinitz under the name *Schizodus obscurus*, in his "Carbonformation und Dyas in Nebraska," agrees more nearly in form, but differs in being decidedly more depressed, with less elevated beaks, and a more truncated posterior outline. It also differs from the shell under

* Mr. Tate has proposed (Geol. Mag., 1868, p. 412) to change the name of this genus to *Axinopsis*, because *Schizodon* had been used, in 1842, by Waterhouse, for a genus of Mammals. This, however, seems entirely unnecessary, the two names, *Schizodus* and *Schizodon*, although identical in meaning, are sufficiently distinct in sound and to the eye to prevent confusion. Other instances of names as nearly alike being both retained in Natural History, might be cited.

consideration, in being sometimes a little sinuous on the posterior basal margin. Another Coal Measure form figured by Prof. Geinitz, under the name *Schizodus Rossicus*, is in some respects still more nearly like our shell, but differs in other characters.

As difficult as it certainly sometimes is to separate closely allied species of this genus, I can not think that we ought to refer to the same species forms found occupying such widely different horizons as the Chemung group of the Devonian, and the Waverly group and Coal Measure of the Carboniferous; on the contrary, it seems to me that we ought generally, under such circumstances, to regard them as distinct species, although it may not be easy, in all cases, to point out well-defined distinctions in the fossilized shells.

Locality and position: Medina, Ohio. Waverly group of the Lower Carboniferous.

GENUS GRAMMYSIA, DeVerneuil, 1847.

(Bull. Soc. Geol. Fr., IV., 2d ser., 696.)

GRAMMYSIA? HANNIBALENSIS, Shumard (sp.).

Plate 16, figs. 5a, b, c.

Allorisma Hannibalensis, Shumard (1855); Missouri Geological Report, Vol. I., Part II., p. 206, pl. C, fig. 19.

Grammysia Hannibalensis, Hall (1870?); Prelim. Notice Lamellibr. Upper Helderberg, etc., p. 62.

Shell small, transversely subovate or subtrapezoidal, with anterior and umbonal regions gibbous, and the height at the beaks equaling about three-fifths the length; anterior end sloping abruptly from the beaks above, with a straight or slightly concave outline, to the lower end of the lunule, where it narrowly rounds into the base, or is sometimes subangular; base forming a broad semi-elliptic or semi-ovate curve; posterior extremity more compressed, apparently sometimes a little gaping, usually narrowly rounded in outline at the middle, and thence truncated obliquely forward and upward above, to the posterior extremity of the hinge; cardinal margin more or less nearly horizontal, straight, or a little concave in outline, and inflected along its entire length so as to form a well-defined escutcheon; lunule generally distinctly defined, rather deep, and presenting an obovate outline; beaks prominent, strongly incurved at right angles to the hinge, so as to bring their points nearly or quite in contact; posterior umbonal slopes prominently rounded; posterior dorsal region abruptly compressed, and sometimes separated from the

swell of the umbonal slopes by a faint undefined sulcus extending from immediately behind each beak, obliquely backward and downward to the truncated edges of the posterior ends of the valves. Surface ornamented by usually well-defined concentric ridges and furrows, that are small and very regular on the umbones and strongest anteriorly, but generally become obsolete on the posterior dorsal region; crossing these a small, very obscure sulcus may often be seen extending from each beak nearly directly downward to the base.

Length of a well-developed adult specimen, 1.35 inches; height of do., 0.81 inch; convexity, 0.71 inch.

Although always presenting peculiarities of general physiognomy by which it can be readily recognized, this shell varies much in form, as well as in the size and regularity of its concentric ridges and furrows. The furrow extending down each valve from the beaks, is generally obsolete, or so faintly defined as scarcely to attract attention, though it is quite distinct on some specimens. On some individuals, like that represented by our figure 5*a*, the concentric ridges and furrows are very strongly defined, and comparatively large, while on others they are smaller, as seen in figure 5*c*, and on still others they fade away and become so irregular as not to be readily distinguished, on the lower and posterior parts of the valves, from the marks of growth.

As may be seen by the synonymy, this shell was originally referred by Dr. Shumard to the genus *Allorisma*, King, and more recently it has been referred by others to *Grammysia*, DeVerneuil, with which latter it certainly seems to be rather closely connected through other species. Still it appears to me to be quite as nearly related to Prof. McCoy's genus *Sedgwickia*, as originally founded by him in 1844, on his *S. attenuata*, *S. bellata*, *S. corrugata*, etc., though it is widely distinct from the original typical forms of the group (*Leptodomus*) to which he refers such shells in 1855.

Locality and position: The specimens we have figured are from the Waverly sandstone of the Lower Carboniferous, at Medina, Ohio. It also occurs at Cuyahoga Falls, and various other localities at the same horizon in Ohio, as well as in the yellow arenaceous beds at Burlington, Iowa; also at Hannibal, Missouri, where the specimens described by Dr. Shumard were obtained. It is likewise found at this horizon in Illinois, and is said to occur in the Chemung group (Devonian) in New York and Pennsylvania.

GRAMMYSIA ? RHOMBOIDES, Meek.

Plate 16, figs. 7a, b.

Grammysia rhomboides, Meek (1871); Proceed. Acad. Nat. Sci., Philad., XXIII., 72.

Shell attaining a moderately large size, rhombic-suboval in outline, with height equaling about three-fourths the length, not very convex, the greatest convexity a little before and above the middle; valves without an oblique mesial ridge or fold, closed, or nearly so, all around; basal margin most prominent just behind the middle, from near which it ascends with a nearly straight outline obliquely forward, and more abruptly with a convex outline behind; anterior side truncated oblique forward from the beaks above, and very narrowly rounded near the middle; posterior side less narrowly rounded at the middle, with its upper edge probably sometimes obliquely truncated; cardinal margin equaling about one-third the length of the valves, and inflected so as to form the usual well-defined escutcheon, which narrows backward from the beaks; lunule rather deep, well defined, lance-ovate in form, and as long as the truncated anterior dorsal slope; beaks moderately prominent, not very gibbous or very strongly incurved, and situated a little nearer the middle than the anterior margin; posterior umbonal slopes forming a very obscure rounded ridge, between which and the dorsal and posterior dorsal margins there is a rather narrow, slightly concave, or flattened space on each valve. Surface with only small marks or lines of growth, which are gathered into very small obscure wrinkles along the margins of the lunule.

Length, 2.90 inches; height, measuring vertically from the most prominent part of the base to the horizon of the tops of the beaks, 2.15 inches; do., to cardinal margin behind the beaks, 1.93 inches; convexity, 1.40 inches.

I only know this shell from casts which show neither the nature of the hinge nor the muscular or pallial impressions. It presents no traces of the characteristic oblique mesial fold or ridge seen in the typical forms of *Grammysia*, and might, when its cardinal margin and lunule are concealed in the matrix, be mistaken for a large *Schizodus*. Its well-defined lunule and escutcheon, however, and obsolete muscular impressions, show that it can not be even nearly related to that group. As the casts show no indications of the characteristic internal cartilage process of *Edmondia*, and it does not seem to have the habit of *Cardiomorpha*, I know of no genus to which it appears to be more nearly related than to

Grammysia, and have concluded to place it provisionally in that group, until its relations can be more precisely determined from the study of better specimens.

Locality and position: Same as last.

GRAMMYSIA VENTRICOSA, Meek.

Plate 16, figs. 6a, b (and pl. 13, figs. 5a, b, var.)

Grammysia ventricosa, Meek (1871); Proceed. Acad. Nat. Sci., Philad., XXIII., 73.

Shell attaining a moderate size, extremely ventricose, the convexity being greater than the height, with the greatest gibbosity a little in front of and above the middle; height equaling about half the length; posterior side comparatively long, a little gaping and narrowly rounded in outline at or a little above the middle; pallial margin usually slightly sinuous near the middle, or in front of it; anterior side very short, concave just under the beaks to the base of the lunule, where the margin is subangular, or very abruptly rounded and most prominent, while below this it curves obliquely backward into the base; cardinal margins scarcely more than equaling half the entire length of the valves, and inflected so as to form the usual shallow escutcheon; beaks very gibbous, moderately elevated, oblique, strongly incurved, and placed almost over the anterior margin; lunule deep, ovate or obovate, and well defined; posterior umbonal slopes prominently rounded; flanks without any oblique ridge or sulcus. Surface marked on the anterior side of the valves, near the lunule, by small wrinkles, which pass into mere lines and linear furrows of growth farther back, while even the latter become nearly or quite obsolete over the more gibbous parts of the valve.

Length of largest specimen seen, 2.50 inches; height, 1.30 inches; convexity, 1.55 inches.

I know nothing of the hinge or muscular and pallial impressions of this shell, and refer it, like the last, to *Grammysia*, from its form and general appearance. It shows no traces of the oblique ridge and furrows seen on the typical species of that genus, but it is well known that this character is not constant in the group.

Locality and position Same as foregoing.

GENUS EDMONDIA, DeKoninck, 1844.

(Anim. Foss. Carb. Belg., 66.)

EDMONDIA? TAPESIFORMIS, Meek.

Plate 13, fig. 6.

Shell longitudinally suboblong-oval, about once and a half as long as high, rather compressed; posterior side rather obliquely rounded; anterior side very short, rounded, or subtruncate; basal margin forming a long nearly elliptic curve; dorsal very straight, and but very slightly declining posteriorly; beaks anterior, oblique, and scarcely rising above the cardinal margin; umbonal slopes not angular or even prominent. Surface ornamented by regularly arranged, raised concentric lines or small ridges, separated from each other by wider furrows.

Length, 1.81 inches; height, 1.10 inches; convexity, about 0.46 inch.

This species is only referred to the above mentioned genus with great doubt, as nothing is known in regard to the nature of its hinge or other internal characters. It seems to be a thin shell, but does not present the general aspect of *Allorisma*, *Sanguinolites*, *Sedgwickia*, or any of the allied groups, being much more compressed, and apparently closed all around. So far as can be determined from the only specimen yet seen, the cardinal margin does not appear to be inflected as in the most of the palæozoic types believed to belong to the *Anatinidæ*. In a side view it presents somewhat the appearance of a shell figured by Prof. McCoy, under the name *Mastra ovata*, in his Synop. Carb. Fossils of Ireland, pl. 2, fig. 4, excepting that it is proportionally about one-third longer and more compressed. In its proportional length and height it agrees more nearly with another form figured in the same work under the name *Pul-lastra ovalis*, but its extremities are more regularly rounded.

Locality and position: Richfield, Summit county, Ohio. Waverly series of the Lower Carboniferous series.

GENUS CARDIOMORPHA, DeKoninck, 1844.

(Anim. Foss. Carb. Belg., 101.)

CARDIOMORPHA SUBGLOBOSA, Meek.

Plate 15, figs. 6a, b.

Shell subglobose, or a little higher than long, with convexity nearly equaling the length; anterior and posterior margins rounding regularly into the base, and forming with the latter more than three-fourths of a

circle; hinge line very short, ranging nearly at right angles to the vertical axis of the valves, and meeting the upper termination of the posterior margin at an obtuse angle; cardinal margins a little inflected, so as to form a broad, shallow, corselet-like depression; beaks prominent, gibbous, incurved nearly at right angles to the hinge, and located centrally. Surface only showing obscure lines and a few somewhat stronger marks of growth, excepting on the immediate umbones, where there are small regularly disposed concentric wrinkles. Lunule moderately deep, narrow subovate, and not distinctly defined.

Length, 1.47 inches; height, 1.64 inches; convexity, about 1.33 inches.

I know nothing of the hinge and interior of this shell, and merely refer it to the genus *Cardiomorpha* from its similarity of form to some of the short elevated and gibbous forms originally included in that genus by its founder, DeKoninck. It agrees more nearly with the form he refers to *C. oblonga*, Sowerby (sp.), than with any other with which I have compared it, though its beaks are not near so strongly incurved or spiral, and differ in being marked with small regular wrinkles. It is also less gibbous, and does not have the margins of its valves meeting at acute angles, as in that shell, nor does it show any traces of the large concentric undulations seen on the same.

Locality and position: Rushville, Ohio. Waverly group of Lower Carboniferous. Prof. Andrews's collection.

GENUS PROTHYRIS, Meek, 1869.

(Proc. Acad., N. S., Philad., XXI, 172.)

PROTHYRIS MEEKI, Winchell, MS.

Plate 15, fig. 2.

Prothyris Meeki, Winchell (1872); cited from his MS. in Hayden's Nebraska Report, page 223.

Shell transversely elongate-rhombic in outline, with height more than one-third the length, rather convex; basal margin long, nearly straight, or sometimes faintly sinuous near or behind the middle; dorsal outline short, straight, and sub-parallel to the base; posterior extremity very narrowly rounded and prominent below, and nearly straight, with a long, very oblique slope above from the posterior end of the hinge; anterior end quite short, moderately gaping, with its notch shallow and very obtuse; beaks small, oblique, rising little above the hinge margin, rather gibbous, and placed only about one-seventh the entire length from the

anterior end; umbonal slopes very convex, or forming a prominent rounded ridge from the beaks obliquely backward and downward to the posterior basal margin; flanks more or less flattened or contracted along the middle near the basal margin, and thence obliquely forward and upward to the beaks. Surface showing only moderately distinct lines of growth.

Length of a large, mature specimen, 1.07 inch; height, 0.33 inch; convexity, about 0.30 inch.

This species will be at once distinguished from *P. elegans*, the type of the genus, by its much greater convexity, more rhombic outline (caused by greatly more oblique outline of its posterior margin), and particularly by its more shallow and more obtuse anterior notch, and decidedly more prominent umbonal slopes.

Locality and position: Rushville, Ohio, in the Waverly group of the Lower Carboniferous series.

GENUS SANGUINOLITES, McCoy, 1844.

(Synop. Carb. Foss. Ireland, 47.)

SANGUINOLITES? OBLIQUUS, Meek.

Plate 16, figs. 2a, b.

Sanguinolites? obliquus, Meek (1871), Proceed. Acad. Nat. Sci., Philad., XXIII, 13.

Shell so depressed and elongated as to be nearly three times as long as high, rather distinctly convex, particularly along the posterior umbonal slopes, which are more or less angular from the beaks nearly to the posterior basal extremity; pallial margin very nearly straight along most of its length; anterior end extremely short, and a little sinuous on the upper side just in front of the beaks, the sinuosity being caused by a very small, deep lunule, at the lower end of which the margin is a little projecting and angular or sub-angular in outline, and from this little projection it curves obliquely backward into the base; cardinal margin extending back about three-fourths the length of the valves, and inflected so as to form a well defined lanceolate escutcheon along its entire length; posterior side narrowed with a long slope above from the end of the hinge to the extremity, which is a little gaping and very narrowly rounded or almost angular below; beaks strongly depressed, very oblique, compressed below the ridges, very nearly terminal, and with the immediate points incurved over the little lunule. Surface showing only lines

and furrows of growth, with occasional small, obscure concentric wrinkles that are not regularly arranged.

Length, 2.13 inches; height, 0.77 inch; convexity, 0.70 inch.

This species seems to be nearly related to a form from the same rock at Medina, Ohio, specimens of which were loaned by Dr. Newberry to Prof. Hall sometime back, and returned with the name *Sanguinolites æolus* attached. A careful comparison, however, of good specimens of each shows them to be clearly distinct, the form under consideration being much more convex along the umbonal slopes, which are also more angular. Its beaks likewise differ in being decidedly more nearly terminal and the inflection of its cardinal margin wider. The specimens of *S. æolus* also show faint traces of two or three very obscure longitudinal ridges above the umbonal angle of each valve, and impressions in casts, of a slight ridge behind the anterior muscular impression, that are not seen in our shell.

From the little that is now known of the shell that will probably have to be regarded as the type of the genus *Sanguinolites*, it is impossible to determine whether or not such species as this can be properly referred to that genus. They seem to agree, however, more nearly with the same than they do with the typical forms of *Allorisma*, to which they are also related.

Locality and position: Rushville and Newark, Ohio. Upper part of the Waverly group of the Lower Carboniferous.

SANGUINOLITES ÆOLUS, Hall.

Plate 16, figs. 1a, b, c.

Sanguinolites æolus, Hall (1870 ?), Preliminary Notice of the Lamellibranchiate Shells of the Upper Helderberg, Hamilton and Chemung groups, etc., page 46.

Shell depressed, sub-elliptic, rather compressed, with height equaling about two-fifths the length; basal margin forming a long, semi-elliptic curve, or sometimes nearly straight along the middle and curving up gradually at the extremities; dorsal margin behind the beaks, long, sub-parallel to the base, nearly straight, or very slightly convex in outline, and abruptly inflected along its entire length so as to form a narrow, lanceolate false area or escutcheon, while in front of the beaks it slopes abruptly forward with a distinctly concave outline to the most prominent part of the front margin, which is above the middle and more or less angular, or very narrowly rounded; beaks small, oblique, compressed laterally, depressed nearly to the dorsal line, and placed about one-

seventh the entire length of the valves behind the anterior extremity; posterior umbonal slopes very oblique, angular at and near the beaks, but becoming more obtuse as they extend obliquely backward and downward to the most prominent part of the posterior margin; flanks below and posterior dorsal regions above the umbonal ridges more or less flattened, while in some specimens a very faint impression may be seen extending from each beak obliquely backward and downward below each umbonal slope nearly to the central region of the base (see fig. 1a, pl. 16). Surface marked with rather distinct concentric lines, and obscure ridges and furrows, crossed sometimes by very obscure traces of radiating lines that are generally quite obsolete on casts, while some specimens show scarcely perceptible indications of two linear radiating ridges, or raised lines on each posterior dorsal region, above the umbonal ridge (see fig. 1c).

Length of largest specimen seen, about 1.71 inch; height, 0.70 inch; convexity, 0.40 inch.

Our figures and description are from some of the original typical specimens of the species, or at least that were labeled and returned to Dr. Newberry, with the name attached, by the author of the species. It seems to be related to the last, but differs in the characters mentioned in the remarks on that species.

Locality and position: Our figured specimens are from the Cuyahoga shale (a part of the Waverly sandstone series), Medina county, Ohio; it also occurs at the same horizon at Newark, Ohio.

GENUS PROMACRUS, Meek, 1871.

(Am. Jour. Conch., VII, 4.)

PROMACRUS ANDREWSI, Meek.

Plate 17, figs. 1a, b.

Sanguinolites (Promacrus) Andrewsii, Meek, 1871, ib., 7.

Shell attaining a large size, elongate-subtrapezoidal, the length being more than three times the height, moderately convex, with flattened flanks; posterior margin obliquely truncated from the posterior extremity of the hinge to the base; basal margin long, nearly straight or but slightly convex in outline; anterior extremity very narrowly rounded; dorsal margin nearly straight and parallel to the base behind the beaks, but declining gently forward with a slightly concave outline in front, where it seems to be inflected so as to form a lanceolate lunule; beaks

nearly central, or located a little in advance of the middle, depressed nearly to the horizon of the dorsal line behind them; posterior umbonal slopes sub-angular near the beaks, but becoming more prominently rounded along a line between the posterior basal extremity and the umbonal region; ligament apparently extending nearly the whole length of the cardinal margin behind the beaks, more or less prominent externally, but apparently extending rather deeply between the margins all the way along. Surface with moderately distinct ridges and furrows of growth, most clearly defined on the anterior slope, where they seem to be somewhat interrupted by obscure traces of radiating furrows.

Length, about 6.90 inches; height, about 2.22 inches; convexity, 1.60 inches.

This fine species is intermediate in its characters between *P. nasutus*, Meek, and *P. Missouriensis*, Swallow. It differs from the latter, however, in having its beaks more nearly central, and its posterior dorsal margin proportionally shorter, as well as in having its anterior dorsal margin more concave in outline, and its posterior umbonal slopes decidedly less angular. The farther anterior position of its beaks, and its obtusely rounded umbonal slopes, also readily distinguish it from *P. nasutus*.

I originally placed this group as a subgenus under *Sanguinolites* of McCoy; but it is more probably distinct generically from that group, though this question can never be positively decided until the hinge of these shells, and that of Prof. McCoy's type, can be known and compared. The species here described is named in honor of Prof. E. B. Andrews, of the Ohio Geological Survey, who discovered the typical specimen.

Locality and position: Sciotoville, Ohio. Waverly group of the Lower Carboniferous.

GENUS ALLORISMA, King, 1844.

(Mag. Nat. Hist., XIV, 316.)

ALLORISMA (CERCOMYOPSIS) PLEUROPISTHA, Meek.

Plate 13, figs. 4a, b, c.

Allorisma (*Sedgwickia*?) *pleuropistha*, Meek, (1871), Proceed Acad. Nat. Sci., Philad., XXIII, 14.

Shell depressed and elongated, or more than twice as long as high, moderately convex centrally and anteriorly, and attenuated and produced behind; pallial margin long, nearly straight along the middle, rounded up anteriorly, and ascending more gradually behind; posterior side very narrow, truncated and somewhat gaping at the extremity, which meets the

cardinal margin at an obtuse angle, and rounds abruptly into the base; anterior side wider (higher) than the other, and more or less abruptly rounded; dorsal margin depressed below the horizon of the beaks behind the latter, where it is concave or nearly straight in outline, and inflected so as to form a short corselet near the beaks, while in front of them it slopes forward rather abruptly, and is provided with a well defined oval lunule; beaks moderately prominent, rather gibbous, and incurved without any obliquity or *fissure*, placed a little less than one-third the length of the valves from the anterior margin; posterior umbonal slopes forming obscure subangular ridges which extend toward the posterior basal extremity, but become obsolete before reaching it, while above this ridge the posterior dorsal region is flattened, or a little concave, and smooth. Surface ornamented with more or less defined concentric wrinkles and lines of growth, which are crossed on the posterior-central regions by linear, but distinct, raised, radiating costæ, separated by wider depressions. Of these costæ the anterior sometimes descend almost vertically from the beaks, with more or less curve, to the base, while farther back they gradually become more oblique, and near the middle of the flanks more closely arranged, but above and behind this they are more widely separated again, and nearly as oblique as the obscure umbonal ridge, above which they are not defined.

Length, 2.28 inches; height, 1 inch; convexity, about 0.85 inch.

This shell strongly reminds me, by its general outline and physiognomy, of those Jurassic species for which Prof. Agassiz proposed the genus *Cercomya*. In that group, however, there is no lunule, and I am not aware that any of the species of the same are marked by radiating costæ as in the species under consideration. From all that is known of its characters I am inclined to believe it more nearly allied to the curious Lyonsia-like carboniferous shells upon which Prof. McCoy originally proposed to found the genus *Sedgwickia*, but which he afterwards referred to the genus *Leptodomus*. Still it differs from this group (*Sedgwickia*) also in the possession of radiating costæ. These costæ are not mere rows of granules such as doubtless existed on nearly all the different types of this family (*Anatinida*), but decided costæ, such as we see in *Pholadomya*; and, what is rather singular, they do not exist on the anterior part of the valves, but extend only as far forward as the beaks, under which they end abruptly, the anterior one being as strongly defined as any of the others, while only the concentric striæ and wrinkles exist on the anterior third of the valves, as well as on the posterior dorsal region. In the possession of the radiating costæ mentioned, as well as in the shortness of its hinge, the inflection of its cardinal margin, and in its general

physiognomy, it differs from the typical species of *Allorisma*, and hence it may be thought desirable to establish a subgenus for its reception, in which case I have elsewhere proposed for the group the name *Cercomyopsis*.

Along with the typical specimen of the foregoing species another was found, with the same form and surface characters, excepting that its anterior end, in front of the beaks, is shorter, and more angular at the lower end of the lunule, while the anterior of its radiating costæ are directed much more obliquely backward, instead of descending nearly vertically from the beaks to the base. This specimen (see fig. 4b) has the posterior end broken away, but as the peculiarities mentioned seem not due to any distortion, it may possibly belong to another species; if so, *Allorisma* (*Sedgwickia*?) *obliqua* would be a good name for it.

Locality and position; Rushville, Ohio. Waverly group of Lower Carboniferous. Prof. Andrews's collection.

ALLORISMA WINCHELLI, Meek.

Plate 16, figs. 3a, b, c.

Allorisma Winchelli, Meek (1871), *Proceed. Acad. Nat. Sci.*, Philad., XXIII, 167.

Shell of about medium size, elongate subelliptic, the length being equal to about three and a half times the height, moderately convex; posterior extremity a little gaping, obliquely subtruncated above and narrowly rounded below the middle; anterior extremity very short, closed, concave in outline obliquely forward and downward from the beaks above to the lower end of the lunule, where it is subangular, and from this point rounding off obliquely into the base; ventral margin forming a broad, gentle curve, but generally somewhat straightened, or sometimes faintly sinuous near the middle; dorsal margin nearly straight, or a little concave in outline, and showing the usual inflection, which forms a lanceolate escutcheon with a slight ridge on each side, from the beaks to the posterior extremity of the hinge, which equals about three-fourths the entire length of the valves; beaks much depressed, very oblique, incurved, and located only about one-fourteenth the entire length of the shell from the anterior extremity; posterior umbonal slopes merely somewhat prominently rounded; anterior umbonal slopes generally slightly subangular near the beaks, and sometimes this prominence is obscurely continued as a faint rounded ridge obliquely backward and downward to a point a little in advance of the middle of the base. Surface ornamented with concentric lines and ridges of growth, that generally assume the character of little regular wrinkles on the umbones. Lunule small, rather deep, moderately well defined, and obovate in form.

Length of a mature specimen, 1.74 inches ; height to middle of dorsal side, 0.83 inch ; do. to horizon of beaks, 0.87 inch ; convexity, 0.70 inch ; length of hinge line, 1.17 inches.

This is a very neat, symmetrical species, often found in an excellent state of preservation as casts of the exterior, showing perfectly the form and surface-markings, excepting the fine granulations usually, if not always, existing in species of this genus. Like some other species of the group, it varies considerably in form, some individuals being proportionally shorter and higher than others. In size and general appearance it sometimes closely resembles *A. clavata* of McChesney, from the Chester group. It does not resemble the particular *variety* of that shell, however, figured by Prof. McChesney, so nearly as it does what I have always believed to be the usual form of the same ; his typical specimen having the beaks more prominent and farther removed from the anterior end than in the more normal form of the species, and its dorsal outline straighter and more sloping posteriorly, with the valves more compressed. Compared with specimens that I have referred to, *A. clavata* from the Chester group of West Virginia, collected by Prof. Stevenson, our Waverly species is found to agree very nearly with some individuals of the latter, though it always has its ridges of growth less strongly defined and more irregular, and its anterior basal margin usually more oblique. It also differs in the possession of an obscure anterior umbonal ridge extending from the beaks obliquely backward and downward nearly or quite to the basal margin, a little in advance of the middle.

The specific name is given in honor of Prof. A. Winchell, the able State Geologist of Michigan, who has described many fossils from the same horizon in the western States.

Locality and position: Rushville and Newark, Ohio. Upper part of the Waverly group of the Lower Carboniferous.

ALLORISMA VENTRICOSA, Meek.

Plate 16, figs. 4a, b.

Allorisma ventricosa, Meek (1871), *Proceed. Acad. Nat. Sci., Philad.*, XXIII, 168.

Shell subovate, the length being about once and a half the height, moderately convex ; posterior margin obliquely subtruncated above, and narrowly rounded or subangular near the middle ; thence curving obliquely under and forward ; base rather deeply and somewhat irregularly rounded, the most prominent part being near the middle ; anterior side short, with an obliquely truncate or concave forward slope above, to the lower extremity of the lunule, where there is a more or less angular

projection, below which the margin curves with a slightly convex outline obliquely backward and downward sometimes nearly to the middle of the base; dorsal margin more or less concave in outline, and showing the usual lanceolate escutcheon margined on each side by a subangular ridge; hinge equaling about two-thirds the length of the valves; lunule rather small, deep, well defined, and narrow-subovate in form; beaks moderately prominent, oblique, and placed about one-seventh the length of the valves from the anterior end. Surface ornamented by small, irregular ridges and furrows of growth.

Length, 1.46 inches; height to cardinal margin, 0.98 inch; do. to horizon of beaks, 1.03 inches; convexity, 0.66 inch; length of hinge, 1 inch. Another specimen, 1.54 inches in length, has a convexity of 0.75 inch.

It is quite possible that this may be only a variety of the last, but as I have before me ten good specimens of that shell, and two of the form under consideration, and there are among them no intermediate gradations between the two forms, I can but regard them as distinct species. The shell here described differs from the last, with which it was found associated, in being proportionally decidedly shorter and wider (higher), as well as in having its ventral margin much more prominent or deeply rounded in the central region. Its beaks are also less oblique, rather more prominent, and proportionally farther from the anterior end. It shows some faint traces of a similar anterior oblique umbonal ridge to that seen in the preceding species, but it is less distinct, and does not show so decided a tendency to become angular at the beaks.

Locality and position: Rushville, Ohio. Waverly group.

GASTEROPODA.

GENUS PLATYCERAS, Conrad, 1840.

(Prelim. Report Palæont. N. Y., 205.)

PLATYCERAS (ORTHONYCHIA ?) LODIENSE, Meek.

Plate 13, figs. 1a, b.

Platyceras (Orthonychia?) Lodiense, Meek (1871), *Proceed. Acad. Nat. Sci., Philad.*, XXIII, 170.

Shell rather small, non-spiral, or merely having the form of a rapidly expanding cone, with a backward obliquity that brings the apex nearly over the posterior margin; lateral slopes nearly straight or slightly concave, and converging to the apex at an angle of about 80°; posterior side vertical and decidedly concave in outline; anterior slope a little more than twice as long as the height of the posterior side, moderately convex

in outline, and provided with a ridge or obtuse carina along its entire length; aperture oval-suborbicular, being slightly longer than wide; lip more or less sinuous at the middle of the anterior side, on one or both sides of the termination of the central ridge of the anterior slope, which ridge terminates in a little projection at the margin. Surface marked by fine lines of growth, which are most distinct on the anterior slope, where they curve backward as they approach the mesial ridge, and then abruptly forward in crossing the ridge; extremely faint traces of minute radiating striae apparently also exist; apex rather abruptly pointed and directed backward without any lateral obliquity.

Length, measuring obliquely from apex, 0.97 inch; breadth, 0.82 inch; length from anterior to posterior margin, 0.90 inch; height of apex, 0.44 inch.

This species is remarkable for its regular, depressed, obliquely conical form and non-spiral apex, which is merely obtusely pointed and directed backward without the slightest lateral curve. It therefore departs widely in form from the typical species of *Platyceras*, and agrees more nearly with an Oriskany shell described in the third volume of the Palæontology of New York, under the name *Cyrtolites? expansus*, excepting that its apex is not so attenuated and produced. Although probably not a true *Platyceras* it seems to me more nearly allied to the section of the same, for which the name *Orthonychia* has been proposed, than to *Cyrtolites*, which was founded on a very different type (*C. ornatus*, Con.), with a peculiar style of ornamentation. In its surface markings our shell agrees with *Platyceras*, being merely marked with fine lines of growth, more or less undulated on the anterior slope, while the traces of very fine radiating striae indicate relations to the section *Orthonychia*, with which the shell also agrees more nearly in its non-spiral form. It therefore bears the same relations to the elongated forms of *Orthonychia* that those depressed, rapidly expanding species of *Platyceras*, such as *P. calanticum* and *P. obesum*, bear to the typical forms of the latter genus.

Locality and position: Lodi, Ohio. Waverly group of Lower Carboniferous.

GENUS PLEUROTOMARIA, DeFrance, 1826.

(Dict. Sci. Nat., XLI, 381.)

PLEUROTOMARIA TEXTILIGERA, Meek.

Plate 13, figs. 7a, b.

Pleurotomaria textiligera, Meek (1871, Proceed. Acad. Nat. Sci., Philad., XXIII, 176.

Shell attaining a medium or somewhat larger size, turbate or rhombic, suboval in general outline, with height a little greater than the

breadth; spire depressed conical; volutions four or five, flattened exactly on a line with the slope of the spire from the apex to near the middle of the last turn, where there is more or less defined angle; last turn large, somewhat ventricose below the angle, and produced so as to make this angle near the middle of the entire bulk of the shell; umbilical region a little excavated, the excavation apparently being continued as a small perforation up into the axis; aperture, as inferred from sections of the body volution, obliquely rhombic-oval; suture merely linear, or sometimes very narrowly channeled between the middle volutions; spiral band occupying, and slightly truncating, the angle of the body volution, where it is flat or a little concave, and passing around immediately above the suture on the volutions of the sphere, excepting on some of the upper turns, where it seems to sink nearly or quite below the suture line. Surface very neatly cancellated by distinct, regular, curved, thread-like transverse and revolving lines, of about equal size and distance apart, the former becoming much finer and arched backward in crossing the band.

Height of a large specimen, 1.42 inches; breadth of revolving band on body volution, 0.10 inch; angle of spire, 70° to 80° .

I was for some time inclined to think this might be the form described by Dr. White and Mr. Whitfield, from the same horizon at Burlington, Iowa, under the name *Pleurotomaria Mississipiensis*, but on comparison with a sketch of the typical specimen in the Museum of the University of Michigan, sent to me by Prof. Winchell, I find it to be quite distinct. The type specimens of *P. Mississipiensis* are natural casts, but Prof. Winchell's sketches show that they differ from casts of the species under consideration in having the angle of the body volution continued on those of the spire distinctly above the suture, so as to give them a turreted appearance instead of being all flattened exactly on a line with the slope of the spire. It also has the spire more elevated than that of our shell, and the upper slope of the body volution concave instead of flat. Indeed, White and Whitfield's species is more nearly allied to *P. tabulata* of Conrad, from the Coal-Measures, than it is to that under consideration.

Locality and position: Medina, Ohio. Waverly group of the Carboniferous, where it seems to be quite abundant.

PTEROPODA.

GENUS CONULARIA, Miller, 1818.

(Sowerby's Min. Con., .)

CONULARIA MICRONEMA, Meek.

Plate 18, figs. 1a, b, c, d.

Conularia micronema. Meek (1871,) Proceed. Acad. Nat. Sci., Philad., XXIII, 84.

Shell elongate-pyramidal, with the sides equal and diverging from the apex at an angle of about sixteen degrees; lateral surfaces nearly flat, and without any mesial furrow, but sometimes showing a very faint, slender mesial ridge, that becomes nearly or quite obsolete toward the smaller end; each of the four angles a little rounded and provided with a shallow, moderately distinct longitudinal furrow. Surface with numerous extremely small, closely crowded transverse striæ, of very nearly the same size on all parts of the shell; striæ gently arching forward as they cross the side, and scarcely interrupted at the little mesial longitudinal ridge, minutely crenate, and separated by extremely slender linear furrows, numbering fifteen in the space of one-tenth of an inch, on all parts of the surface; crenulations of striæ twelve to fifteen in one-tenth inch.

Length of a specimen broken at both ends, with a diameter of 0.96 inch at the larger end, and 0.46 inch at the smaller, 2.30 inches.

This species is remarkable for the extreme fineness and closely crowded uniform character of the transverse striæ on all parts of the surface. I know of no other species resembling it in other respects, with near such fine, crowded striæ. At a little distance these lines are often entirely invisible to the unassisted eye, and it requires the aid of a magnifier to see them distinctly. The furrows between these striæ are mere impressed hair lines in which no crenulations are visible in the specimen.

Locality and position: Sciotoville, Ohio. Waverly or lowest division of the Carboniferous.

CONULARIA NEWBERRYI, Hall.

Plate 18, figs. 2a, b.

Conularia Newberryi, Hall.*

Shell attaining a moderately large size, presenting the usual elongate-pyramidal form, with equal or subequal lateral surfaces diverging from the apex at an angle of about sixteen degrees; sides a little convex, and

* I have not been able to find Prof. Hall's description of this shell, and only know that the form here described has been generally identified with it.

showing an obscure, undefined mesial line; each of the four angles more or less rounded and strongly furrowed. Surface with distinct, sharply-elevated, finely-crenate transverse costæ, that are separated by larger furrows, and all arching a little forward from the angles to an indistinct mesial line, along which their inner ends sometimes terminate alternately, or are, in other instances, directly continuous across, without interruption; number of costæ in 0.51 inch, where the sides measure 0.85 inch across, eleven to twelve, and each bearing about fifteen crenulations in 0.18 inch at the same place; furrows between the costæ apparently smooth.

Length apparently from three to four inches.

This species will be at once distinguished from the last by its very much larger and more distant costæ, which apparently also differ in increasing regularly in size, as well as in their distance apart, from the smaller to the larger extremity, instead of continuing of nearly the same size. Cross sections indicate a slightly greater diameter in one direction than at right angles to the same, but this may be due to accidental pressure. As far as can be seen in the specimens examined, the rather wide furrows between the costæ seem to be smooth, or with only faint traces of minute striæ of growth.

Locality and position: The original type specimens of this species were found in the Waverly group of the Lower Carboniferous. The example from which the foregoing description and our figures were prepared, came from the same horizon at Loudonville, Ohio.

CRUSTACEA

ENTOMOSTRACA.

GENUS CERATIOCARIS, McCoy.

? SUBGENUS COLPOCARIS, Meek, 1872.

(Proceed. Acad. Nat. Sci., Philad., XXIV, 333.)

On first examining the species here placed under the above subgeneric name, their general similarity to certain forms that have been referred to *Ceratiocaris* of McCoy was readily perceived, but a critical comparison with the figures and descriptions of Prof. McCoy's original typical species of that group, such as his *C. solenoides*, *C. ellipticus*, and his more recently described *C. ornatus* from the Silurian, satisfied me that our species present differences of apparently more than specific importance. I therefore sent some of the specimens to Prof. Dana, of New Haven, with the

view of obtaining his opinion respecting their relations to the genus *Ceratiocaris*, and he informed me that Dr. S. I. Smith, of that city, and himself concur in the opinion that they do not properly belong to the same genus as the typical forms of *Ceratiocaris*.

The differences to which I allude consist first in the general form of the carapace valves, which, instead of being truncated with a nearly straight outline from below forward and upward, are truncated backward and upward, with a *profoundly sinuous outline*, the sinus being directed somewhat obliquely forward and upward, while the posterior extremity of the dorsal margin is produced, pointed, and curved downward. Again, they show a peculiar inflection of the ventral margin, which gives it a more or less carinate appearance. In the species *C. Bradleyi*, this margin is always fixed along this line at an acute angle inward and upward, while in the species *C. elytroides* it is less strongly inflected, though the linear carina is well defined, and sometimes minutely crenated. This last mentioned species also shows another linear, minutely crenate carina or ridge near the dorsal margin, and would, therefore, bear some resemblance to *Dithyrocaris* in this respect, but otherwise, particularly in the form of its carapace valves, it is quite distinct from that type.

It is also worthy of note that none of the specimens yet obtained show any traces of an ocular tubercle or spot, so constantly seen in the typical species of *Ceratiocaris*. Again, they always present a clear, smooth outline to the dorsal margin of the carapace valves, thus indicating that they were merely connected there by a kind of flexible ligament, while the valves of *Ceratiocaris* were supposed by Prof. McCoy to be anchylosed, and rigidly united at a fixed angle along the dorsal margin.

I have little or no doubt in regard to the importance of some, if not all, of these differences, but from deference to the general reluctance of geologists and some palæontologists to accept new genera separated under such circumstances, I merely proposed, in first describing the following species, to arrange them provisionally as a subgenus of *Ceratiocaris*, under the name *Colpocaris*, in allusion to the sinus of the posterior margin. The same arrangement is also continued, provisionally, here.

CERATIOCARIS (COLPOCARIS) BRADLEYI, Meek.

Plate 18, figs. 6a, b, c, d, e.

Ceratiocaris (Colpocaris) Bradleyi, Meek (1872); Proceed. Acad. Nat. Sci., Philad., XXIV, 332.

Carapace valves large, rhombic-subelliptic, more than twice as long as high, moderately convex; dorsal margin forming a broad, depressed arch from end to end; ventral margin more deeply arched downward than

the dorsal is upward, its most prominent part being near the middle, along which the inflected edge is directed upward and inward, while its entire length, owing to the obliquity of the posterior end, is shorter than the dorsal margin; posterior margin very deeply and somewhat obliquely sinuous, thus causing the downward-curved, posterior-dorsal extremity to project considerably farther backward than the end of the basal margin below the sinus; anterior end narrowed, with its margin rounded up from below so as to connect with the dorsal nearly at a right angle above. Surface smooth to the unassisted eye, but showing under a magnifier very minute reticulated markings.

Length about 2.75 inches; height, 1.25 inches.

This species agrees most nearly, in size and form, with *Ceratiocaris* (*Colpocaris*) *sinuatus*, Meek and Worthen, from the Lower Coal Measures of Grundy county, Illinois, and was found by Prof. Bradley enveloped in exactly the same way in concretions. It differs, however, specifically in being proportionally narrower in its vertical diameter, with the most prominent part of its basal margin more nearly central. It also differs in having its posterior dorsal extremity more produced and more pointed, as well as more curved downward, while that of its lower margin is proportionally shorter, owing to the obliquity of the deep sinus of the posterior end of the valves.

Associated with these fossils Prof. Bradley also found the caudal appendages (telson and stylets) probably of this species, judging from their comparatively large size. One of these specimens has these appendages 1.35 to 1.40 inches in length, and about 0.10 inch in breadth, at the larger end, the telson being apparently slightly shorter than the stylets, (see fig. 6*d*, of plate 18).

The specific name was given in honor of Prof. Frank H. Bradley, of Knoxville, Tennessee, to whom I am indebted for the use of the type specimens. The large specimen represented by fig. 6*a* is considered the type of the species.

Locality and position: Base of the Waverly group, at Danville, Kentucky. Prof. Bradley's collection.

CERATIOCARIS (*COLPOCARIS*) ELYTROIDES, Meek.

Plate 18, figs. 5*a*, *b*, *c*.

Ceratiocaris (*Colpocaris*) *elytroides*, Meek (1872), Proceed. Acad. Nat. Sci., Philad., XXIV, 334.

Carapace valves narrow-subelliptic, about twice and a half to three times as long as high, and rather distinctly convex; anterior end narrower than the other, and subangular or narrowly rounded above; dorsal

margin gently arcuate from end to end, and terminating behind in a pointed projection that extends a little farther backward than the lower margin, and curves distinctly downward; posterior margin truncated obliquely from above forward and downward, and very deeply sinuous, the sinus being directed a little upward and forward; basal margin most prominent near the middle, and behind this straight, or sometimes very faintly sinuous, and ascending to the rather obtusely pointed, posterior basal extremity, while from near the middle forward it ascends gradually, at first, with slight convexity of outline, and farther forward with a stronger upward curve until it intersects the dorsal margin above. Surface with an obscure, linear, sometimes minutely crenate carina, or raised line along near, but not exactly parallel, to the lower margin (being most remote from it along near the middle), and another similar but more distinctly crenate carina, running along parallel to and about one fifth the height of the valves below the dorsal margin, otherwise appearing to the unassisted eye as if perfectly smooth, but when examined in a favorable light, by the aid of the highest power that can be conveniently used as a hand magnifier, seen to be very beautifully and minutely striated, the striæ being very regular, closely arranged, and more or less divaricating from the carinæ.

Length of carapace valves, 1.25 inches; height, 0.46 inch; convexity of each valve, 0.09 inch.

This species may be readily distinguished from the last, not only by its smaller size, but by its narrower form and two minutely crenate longitudinal carinæ, but particularly by the different nature of its microscopical sculpturing, that of the last described species presenting a delicate reticulated appearance, instead of minute hair lines. The basal margins of its valves, below the carina, are also only a little deflected inward and downward, while in all the specimens of the last yet seen, they are abruptly deflected at an acute angle inward and upward.

Locality and position: Same as last.

SUB-GENUS SOLENOCARIS, Meek, 1872.

(Proceed. Acad. Nat. Sci., Philad., XXIV, 335.)

I did not submit this form to Prof. Dana, but as it differs quite as materially (though in other respects) from the typical forms of *Ceratiocaris* as those I sent to him do, and as widely, or even more widely, from those I sent than the latter do from *Ceratiocaris* proper, I have ventured to separate it under a distinct subgeneric name. Like the last described

type, it shows no traces of ocular spots, while it has the posterior end merely subtruncated very obliquely backward from below, but not in the slightest degree sinuous. At a first glance it looks like the valves of a narrow, elongated bivalve mollusk, but its sculpturing is decidedly of crustacean type, being like that of some species of *Ceratiocaris* proper. It shows no indications of having its valves anchylosed along the dorsal margin.

CERATIOCARIS (SOLENOCARIS) STRIGATA, Meek.

Plate 18, figs. 4a, b, c.)

Ceratiocaris (Solenocaris) strigata, Meek, (1872); *Proceed. Acad. Nat. Sci., Philad., XXIV.*, 335.

Carapace valves narrow and elongated, the length being about four times the height, rather distinctly convex; dorsal and ventral margins nearly straight and parallel; anterior very narrowly rounded, the most prominent part being at the middle; posterior end so obliquely truncated as to impart a pointed appearance to the posterior dorsal extremity, which is not curved. Surface showing well-defined, comparatively rather coarse, more or less anastomosing longitudinal striæ, that seem not to curve exactly parallel to the anterior and lateral margins, and are usually more or less impressed upon internal casts.

Length, 1.24 inches; height, about 0.30 inch; convexity, about 0.23 inch.

Locality and position: Same as last. Prof. Bradley's collection.

TETRADECOPODA.

? GENUS ARCHÆOCARIS, Meek, 1872.

(*Proceed. Acad. Nat. Sci., Philad., XXIV.*, 335.)

ARCHÆOCARIS VERMIFORMIS, Meek.

Plate 18, fig. 7.

Archæocaris vermiformis, Meek (1872); *Proceed. Acad. Nat. Sci., Philad., XXIV.*, 335.

The specimens of this fossil yet known are too imperfect to be systematically characterized, but it may be described, in a general way, as follows, the description being intended to apply to a side view of an individual, as seen more or less compressed laterally in concretions:

Cephalothorax, or head, about equaling the length of the first three and a half of the body segments behind it; subtrigonal in form, being some-

what pointed in front, with the posterior margin wider, obliquely truncated from above backward and downward, and sinuous, so as to give more or less angularity to the posterior basal extremity; basal margin apparently with a kind of ridge or fold along most of its length, and ascending with a slightly convex outline forward, so as to meet the dorsal margin (which is more nearly horizontal) at a rather acute angle in front; eyes (if there are any) unknown; abdomen or body with the six segments of nearly equal size, and strongly imbricating; telson apparently as long as three of the abdominal segments, flattened, of moderate breadth anteriorly, and tapering behind; stylets not clearly seen, but apparently one on each side of the telson. Other abdominal appendages unknown. Surface of all parts smooth.

Length of head or cephalothorax, from the anterior to the posterior basal extremities, 0.34 inch; height, 0.18 inch; length of the six body or abdominal segments, 0.51 inch; height, 0.16 inch; length of telson unknown.

In one of the specimens there is a leg-like appendage, seen in the matrix extending close along under and parallel to the basal margin of the head or cephalothorax. This appendage, or rather what can be seen of it, consists of three joints, two long and one short. The posterior joint, although apparently broken at the posterior end, is 0.13 inch long, and rather stouter than the next in front of it, which is of the same length. The third joint only shows a little of one end, which connects with the anterior end of the forward one of the two longer joints, and is flexed at right angles to the latter, so as to pass under the anterior margin of the cephalothorax. This may possibly be one of the abdominal appendages bent forward, but it has more the appearance of a stout antenna bent backward. Prof. Dana thinks it most probably the latter.

In regard to the affinities of this type not much can be said without better specimens for comparison. Prof. Dana suggests, however, that it may possibly have some relations to the recent genus *Cuma*. Being unable to find any defined genus to which it can be properly referred, I proposed for its reception a new genus under the name *Archæocaris*, in allusion to the ancient period of its existence.

Locality and position: Same as preceding.

TRILOBITA.

GENUS PHILLIPSIA, Portlock, 1843.

(Report Geol. London, etc., 305.)

PHILLIPSIA (GRIFFITHIDES?) LODIENSIS, Meek.

Plate 18, fig. 3.

Compare *Phillipsia insignis*, Winchell (1863); Proceed. Acad. N. S., Philad., XV., 24.

Rather small, with an elliptic general outline, the length being somewhat less than twice the breadth; cephalic shield forming rather more than a semicircle, with the posterior lateral angles terminating in acutely pointed spines that extend back to the third thoracic segment; anterior and lateral margins rounded in outline, and provided with a more or less flattened border, ornamented above with a row of small tubercles,* that extend back a little upon the posterior lateral spines, while it is somewhat thickened and finely striated on the under side; glabella small, longitudinally oval, moderately prominent, separated from the cheeks on each side by a well-defined furrow, but without visible lateral furrows of its own (unless there may be a posterior one on each side separating a little tubercle); whole surface occupied by about twenty-five distinct tubercles or coarse granules; eyes small, tuberculiform, rather prominent, and situated near and opposite the posterior third of the glabella, with the visual surface smooth or very minutely reticulated; cheeks occupied by comparatively coarse, prominent tubercles, like those on the glabella; thorax with middle lobe somewhat wider and higher than the lateral, from which it is separated by well-defined furrows; segments of mesial lobe ornamented with tubercles, arranged so as apparently to form five longitudinal rows; pleuræ each provided with two nodes, arranged so as to form two rows along each lateral lobe, those of the outer row being a little larger than the others, and situated somewhat within the middle of each lateral lobe at the point where the pleuræ bend to form the slope to their lateral extremities; pygidium semielliptic, with length and breadth as three to four, very convex; mesial lobe very prominent and equaling more than one-third the entire breadth at the anterior end, rather rapidly tapering backward to an obtuse, prominent termination before quite reaching the posterior margin, provided with twelve or thir-

* Not represented in the figure, or clearly seen in the specimen drawn, but observed in others.

teen segments, each one of which bears five little nodes arranged so as to form five rows, those of the middle row being larger and more prominent than the others, and thus giving the lobe a carinated appearance; lateral lobes somewhat flattened above for about half their breadth, at which point they bend suddenly downward for a short distance, and then obliquely outward to form a rather broad, sloping border, each provided with seven to nine segments, the posterior of which are very obscure and directed nearly backward, the segments each bearing two or three little nodes arranged so as to form as many longitudinal rows, and all continued down upon and across the sloping border, at the edge of which they terminate in little pointed projections so as to present a fimbriated appearance around the posterior and lateral edges. (This latter character is not represented in the figure.)

Length, 0.49 inch; breadth, 0.28 inch; length of cephalic shield, 0.20 inch; do. of a pygidium of another specimen from Loudonville, in a ferruginous matrix, 0.23 inch in length by 0.30 in breadth, with a height (of mesial lobe) of 0.10 inch.

As the only specimen of this species showing the entire fossil has the head somewhat crushed, it is possible that it may be necessary to modify the description of that part in some of the details when perfect specimens can be examined. This condition of the cephalic shield also renders the generic characters somewhat obscure. The apparently smooth eyes and glabella, without visible lateral furrows, would seem to indicate relations to *Griffithides*, though the form of the glabella is more like that of *Phillipsia*. The fimbriated character of the posterior and lateral margins of the pygidium, however, is very peculiar and hitherto unknown, I believe, in either of the above mentioned genera, though it occurs in one section (*Phæton*) of the allied genus *Proetus*; hence it is possible our species should be called *Proetus* (*Phæton*) *Lodiensis*, as it would not be very surprising that this genus should be here found in this oldest member of the Carboniferous, though hitherto, I believe, only known in the Silurian and Devonian.

Specifically the head of this trilobite resembles *Phillipsia McCoyi* of Portlock, more nearly than any other known to me, particularly in its coarsely tuberculated surface, with a row of tubercles arranged around the anterior and lateral margins, as well as in the oval form of its glabella. Its eyes, however, are proportionally smaller, its occipital ridge much more strongly developed and wider, while the tubercles of its marginal row are not nearly so crowded as in Portlock's species.

So far as can be determined from a description alone, the form under

consideration would seem to be nearly related, in some of its characters, to *Phillipsia insignis*, Winchell. In the description of that species, however, the presence of a row of nodes around the margin of the cephalic shield is not mentioned, and its posterior lateral spines must be decidedly longer than in our species if I correctly understand the description, in which they are said to "reach twice the length of the glabella from the anterior end." In the arrangement of the tubercles on the glabella, and in the possession of well-defined lateral lobes in the same, Prof. Winchell's species also seems to differ, as well as in its "large" eyes. There would likewise appear to be much more important differences in the pygidium, which in our species has the segments of the lateral lobes distinctly continued across the somewhat flattened margin, and terminating in little spine-like projections, so as to give the border a fimbriated appearance, while in *F. insignis* they are merely said to "become indistinct and disappear toward the margin."

Locality and position: In the Cuyahoga shales at Lodi, Medina county, Ohio, and in ferruginous arenaceous beds of the Waverly group at Loudonville, Ohio. Lower Carboniferous.

COAL-MEASURE SPECIES.

MOLLUSCA

POLYZOA.

GENUS SYNOCLADIA, King, 1849.

(Ann. Mag. N. H., 2d ser., III., 388.)

SYNOCLADIA BISERIALIS, Swallow.

Plate 20, figs. 5a, b.

Synocladia biserialis, Swallow (1858), Trans. St. Louis Acad. Sci., I., 179; Meek (1872), Palæont. Eastern Nebraska, in Hayden's Report, U. S. Geol. Survey of Nebraska, 156, pl. VII., figs. 5a-e; also (1874) Am. Jour. Sci. and Arts, 486.

Compare *Septopora Cestriensis*, Prout (1858), Trans. St. Louis Acad. Sci., I., 448, pl. XVIII., figs. 2a, b; Meek and Worthen (1870), Proceed. Acad. Nat. Sci., Philad., 15; Palæont. Illinois, pl. XXIV., figs. 14a-c; Meek (1874), Am. Jour. Sci. and Arts, 486.

Among the specimens from the Lower Coal Measures at Flint Ridge, near Newark, Ohio, there is a *Synocladia* agreeing so nearly with *S. biserialis* of Swallow that I am inclined to regard it as a variety of that species. It grows in very rapidly spreading, foliated, or possibly widely infundibuliform expansions, the stems seeming to radiate from the same point, and throwing off on each side lateral branches, which also give off, in the same way, lateral branchlets. The dissepiments, as in the typical forms of *S. biserialis*, are smaller than the primary and secondary branches, and strongly arched or angulated in passing across, while they give origin to intermediate branches about as often as in the typical specimens of *S. biserialis*, as in the latter there are only two rows of pores on each branch and stem, with minutely nodose mesial ridge or carina between. The pores on the dissepiments are arranged much as in *S. biserialis*, as is also the case with the fenestrules.

The principal differences between these specimens and good examples of *S. biserialis* from Kansas and Nebraska are the following: In the first place, the entire structure of the form under consideration is more deli-

cate, particularly the longitudinal stems and thin branches, all of which are proportionally more slender, so as to form with the dissepiment a finer and more regular reticulated structure. Again, the dimorphous cells of its non-poriferous side are proportionally larger and arranged very regularly on the stems and branches, *one at each end of each dissepiment*, instead of being very irregularly scattered over the whole of the non-poriferous side. If it should be considered desirable to designate this as a distinct variety of *S. biserialis*, or if it should be found from a careful comparison of a good series of specimens to be specifically distinct from *S. biserialis*, it may take the name *S. gracilis*.

Locality and position: Lower Coal Measures, near Newark, Ohio.

GENUS PTILODICTYA, Lonsdale, 1839.

(Murch. Sil. Syst.)

PTILODICTYA (STICTOPORA) SEREATA, Meek.

Plate 20, fig. 4.

Bifurcating or ramose, the bifurcations occurring usually at rather distant intervals, and the divisions generally diverging at right angles from each other; poriferous surfaces nearly flat or much compressed; lateral margins of both stems and branches sharp and smooth, and provided with very short, obtuse or truncated, alternating, closely and regularly arranged lobes, or flattened lateral divisions, standing out at right angles to the margins, and, like the main stems and branches, bearing pores on each side; pores small, apparently without distinctly projecting lips, and arranged in quincunx, so as to form on the stems and branches about six to eight longitudinal rows, generally separated from each other in all directions by spaces about equaling twice the diameter of the pores themselves; surface between the pores smooth or without ridges.

Entire length of stems and branches unknown; breadth, exclusive of the short, lateral projections, 0.12 inch; thickness, about 0.04 inch; number of pores in 0.10 inch, measuring in the direction of the length of the stems, six; do., measuring obliquely, about seven.

This species differs remarkably from all of the others known to me by the possession of the numerous, very short, regularly and closely arranged, obtuse or truncated lateral divisions, given off at right angles from both lateral margins of stems and branches. At first I was inclined to view these as the remains of lateral branches that had been accident-

ally broken away. They are too uniform in length, however, for this, and when carefully examined under a magnifier do not show any indications of having been broken. They are generally about half as wide as the stems from which they spring, near 0.06 inch in length, and are arranged at intervals of about their own breadth apart, with rounded sinuses between, thus giving a crenate or serrated appearance to the margins. The pores continue out on these short, lateral divisions exactly as on the stems, without interruption.

Locality and position: Flint Ridge, Ohio. Lower Coal Measures. Prof. Andrews.

PTILODICTYA (STICTOPORA) CARBONARIA, Meek.

Plate 20, figs. 3a, b.

Ptilodictya (Stictopora) carbonaria, Meek (1871); Proceed. Acad. Nat. Sci., Philad., XXIII., 160.

Ramose, branches from their origin generally nearly equaling the breadth of the stems, from which they spring more or less alternately, and at angles generally of about 50° to 60°; poriferous surface of each side flattened-convex; lateral margins sharp and smooth; pores of each side arranged in quincunx, so as to form from about seven to nine longitudinal rows (those of each two adjacent rows alternating), and about the same number may be counted in each oblique row, very nearly or quite circular, and each with prominent margins, so as to appear as if penetrating minute pustules; intervening spaces usually once and a half to twice the breadth of the pores, and smooth, or without longitudinal ridges or furrows.

Entire size unknown; breadth of a medium sized branch, 0.14 inch; thickness in the middle, 0.05 inch; number of pores in a space of 0.10 inch of each longitudinal row, six, while in the oblique rows about seven may be counted in the same space.

Among the Silurian species of *Stictopora* this seems to agree most nearly with *S. punctipora*, Hall, from the Niagara group, which it nearly resembles in its round pores with raised margins, as well as in the number and arrangement of its pores. It differs, however, in having its sharp, lateral margins smooth instead of being striated. A critical comparison of specimens would doubtless show other differences. Its branches are narrower, and the number of its longitudinal rows of pores is also less than in a species from the Corniferous limestone I have named *P. Gilberti*, which also differs in having longitudinal ridges between the rows of pores.

Locality and position: Newark, Ohio. Coal Measures.

BRACHIOPODA.

GENUS SPIRIFER, Sowerby, 1815.

[Min. Con., II., 42.]

SPIRIFER (TRIGONOTRETA) OPIMUS, Hall ?

Plate 19, figs. 14a, b, c, d, (e?).

Spirifer opimus, Hall (1858) ; Geol. Report Iowa, I., Part II., Palæont., 711.Compare *S. subventricosus*, McChesney (1860) ; Descriptions Palæozoic Fossils, 44.

Shell attaining nearly a medium size, varying from transversely oblong to truncato-suboval, or approaching semicircular, moderately convex ; lateral margins connecting with the hinge behind at nearly right angles or less, and rounding anteriorly to the front, which is usually broadly rounded in outline, or sometimes subangular at the middle ; hinge line generally equaling the greatest breadth of the valves ; dorsal valve a little less convex than the other, with its beak projecting very slightly beyond the hinge line, and incurved ; mesial fold moderate, very narrow at the beak, and widening more or less rapidly to the front, bearing about five or six rather small plications or costæ, the lateral ones of which often bifurcate once ; lateral slopes each provided with about twelve to fifteen generally simple but sometimes in part bifurcating costæ ; ventral valve rather evenly convex ; beak not very prominent, and more or less incurved ; area and foramen moderate, the former rather well defined and arching with the beak ; mesial sinus commencing very small at the beak, widening to the front, and occupied by about seven costæ, only the marginal ones of which usually extend to the beak, while the others within generally connect with these on each side at various distances between the front and beak ; costæ of the lateral slopes as in the other valve.

Length of a medium sized specimen, 0.80 inch ; breadth, 1.04 inches ; convexity, 0.63 inch.

Like other analogous species of this genus, this varies in form, some specimens being more extended on the hinge line than others, and the number of costæ differing. Usually the costæ are mainly simple, excepting the lateral ones of the mesial sinus and fold, but sometimes a few of those on the lateral slopes also divide once. The form represented by fig. 14e has a narrow mesial sinus, a more extended hinge line, and more numerous plications, and consequently may belong to a distinct species,

though these shells, as stated, vary much in these characters. Both of the forms figured look unlike Prof. Hall's type of *S. opinus*, as illustrated in the Iowa Report, being less gibbous and more transverse, with more numerous plications, but in the Illinois Coal Measures there are shells apparently undistinguishable from *S. opinus*, that seem to shade off into forms like those here figured. In some respects these Ohio shells agree more nearly with *S. subventricosus*, McChesney, which, however, is generally regarded as a variety of *S. opinus*. I have also found it difficult to distinguish all of these shells from *S. Keokuk*, var., Hall (Iowa Report, I., part II., 676, plate XXIV., fig. 4a).

Locality and position: This shell occurs at many localities in the Coal Measures of Ohio, Illinois, Iowa, Missouri, and West Virginia; also numerous places in the Rocky Mountain region of the far West.

MOLLUSCA (PROPER).

LAMELLIBRANCHIATA.

GENUS AVICULOPECTEN, McCoy, 1851.

(Ann. Mag. Nat. Hist., VII., 171.)

AVICULOPECTEN (STREBLOPTERIA?) HERTZERI, Meek.

Plate 19, figs 13a, b, c.

Shell usually under medium size, higher than wide, rather compressed, the right valve being nearly flat, and the left only moderately convex; subovate in general outline (exclusive of the small ears), with a slight backward obliquity, caused by the greater prominence of the anterior margin; basal outline semicircular and rounded regularly into the rather prominently rounded anterior margin; posterior margin less prominent than the anterior, and forming a longer and more gentle curve from the posterior ear into the base; hinge distinctly shorter than the antero-posterior diameter of the valves; posterior ear in both valves very small, flattened, very obtusely angular, and much shorter than the margin below, from which it is only separated by a faint sinuosity, though it is well defined from the umbo; anterior ear of each valve distinctly larger than the posterior, though not nearly as prominent as the anterior margin below, rather strongly compressed or flattened, so as to be abruptly separated from the umbo, and in both valves defined by a distinct sinus from the margin below, the sinus being deeper and more angular in

the right valve; beaks compressed, scarcely projecting above the cardinal margin, and placed a little behind the middle of the hinge, as well as that of the valves. Surface of both valves elegantly ornamented by numerous, sometimes sharply elevated, nearly equal, very regularly arranged radiating and concentric lines, which are larger and more strongly defined on the anterior ear of the right valve, particularly the radiating markings, which there sometimes assume the character of small costæ, while the concentric markings there in some examples project as little lamellæ slightly above the hinge margin, so as to give it a subdentate appearance.

Height of one of the largest specimens seen, 1.32 inches; antero-posterior diameter, 1.20 inches; convexity, about 0.18 inch.

I know of no other shell in our rocks that is liable to be confounded with this, its general form and neatly cancellated markings being sufficient to distinguish it. Although I refer it provisionally to *Aviculopecten*, I really do not think it belongs properly to that genus, as restricted to the typical forms. At least it differs from all the characteristic forms of *Aviculopecten* in having the anterior ear larger than the posterior, as well as in having its beaks placed a little behind the middle of the valves, thus giving the slight backward obliquity mentioned in the description. This latter character seems to approximate it to *Streblopteria* of McCoy, but as we know nothing of its hinge and interior, it is not possible to determine whether it belongs to that group or not.

The specific name is given in honor of the Rev. H. Hertzner, of the Ohio Geological Survey, to whom I am indebted for the use of some fine specimens from his own private collection.

Locality and position: Newark, Ohio. Lower Coal Measures.

GENUS PLACUNOPSIS, Morris and Lycett, 1853.

[Monogr. Fossils Great Oolite, 6.]

PLACUNOPSIS RECTICARDINALIS, Meek.

Plate 19, fig. 12.

Shell truncato-suboval or subquadrilateral, slightly oblique, with length and breadth nearly equal; cardinal margin straight, not quite equaling the greatest breadth of the valves; lateral margins almost straight and parallel, meeting the hinge at nearly right angles, and rounding regularly to the rounded ventral edge; upper valve depressed, most convex

between the beak and central region; beak small, depressed, and but slightly projecting beyond the cardinal margin, near the middle of which it is placed with scarcely perceptible obliquity; surface showing fine, obscure lines, and a few stronger marks of growth, with faint traces of radiating striæ, and an entirely distinct set of regular, transverse, waved or arched, parallel, little linear ridges or costæ, which appear to have resulted from the markings of the surface of the object upon which the shell had grown; lower (right?) valve unknown.

Ventro-dorsal and transverse diameters each about 0.95 inch; convexity of the upper (left?) valve, about 0.13 inch.

The shells of this type seem to vary so much in form that it is barely possible that this may be only an extreme variety of *Placunopsis carbonaria*, Meek and Worthen. (See Illinois Geol. Rep., V., pl. 27, figs. 2a-d.) Its much longer and straighter hinge, however, and angular lateral extremities, with its less prominent, more nearly central beaks, and nearly obsolete radiating striæ, all combine to give it so different an appearance that with such means of comparison as we now have on hand I can but regard it as a distinct species.

It is not possible, from the specimens yet examined, to be absolutely sure that these Carboniferous shells agree exactly with the genus *Placunopsis*, but so far as can be determined they seem to agree quite closely with it. The Illinois specimens show the lower valve to be flat, or at least to conform to the contour of the surface to which it seems to have grown by its whole under surface. It shows no traces of a perforation or sinus for the passage of a byssal plug, as in *Anomia*, while the upper valve, which, from the direction of its slight obliquity, appears to be the left one, always shows a curious mingling of concentric and radiating markings, with an entirely different set of regular, transverse, or oblique lines or ridges, as if the latter had been produced by the markings of some other shell upon which it had grown, as we often see in *Anomia*, *Crania* and some other attached shells.

Baron de Reyckholt has described a genus, *Anomianella*, from the Carboniferous rocks of Tournay, that had a similar habit of growing on other shells, and assuming their style of markings. At one time I thought it highly probable, from a notice I had seen of his genus, that it might include our shells of the type under consideration; but on seeing the figures of his *A. proteus*, which is supposed to be the typical species (I have not yet seen his description), I find it to be an oval shell, without the slightest traces of a straightened cardinal edge or marginal beak. Consequently it is very improbable that our shells can properly be placed

in the same genus. Baron de Reyeckholt probably saw in some of his specimens characters distinguishing his genus from *Crania*, but if I were to form an opinion from his figures only, I should almost be led to think they represented a thin species of that genus.

Locality and position: Coal Measures at Flint Ridge and Putnam Hill, Ohio. Prof. Andrews's collection.

GENUS POSIDONOMYA, Brown, 1837.

(Leth. Geogn., 88, 164 and 342.)

POSIDONOMYA FRACTA, Meek.

Plate 19, figs. 7a, b.

Shell obliquely subovate, compressed, very thin; posterior basal margin regularly rounded; posterior dorsal edge ascending obliquely forward to the hinder extremity of the hinge, which it meets at an obtuse angle; anterior margin descending or truncated more or less nearly vertically from the beaks above, and rounding obliquely into the base below; hinge line straight, very short, and ranging at an angle of about 45° to 60° above the longer oblique axis of the valves; beaks terminal, very oblique, and projecting very little or not at all above the hinge margin; surface marked by regular concentric undulations, with intermediate parallel striæ.

Length of a narrow right valve, 0.72 inch; breadth of same, 0.43 inch; length of hinge, 0.22 inch.

As may be seen by the figures, this little shell presents exactly all the external characters of an oblique *Inoceramus*, the smaller right valve represented by fig. 7a being, in form and ornamentation, an *exact* miniature of the well known cretaceous *Inoceramus problematicus*. I know nothing of the hinge of these shells, but there is, of course, no probability that they belong to the genus *Inoceramus*, and it is scarcely possible that *I. problematicus*, which is unknown in any intermediate position, could occur both in the Cretaceous and Carboniferous rocks, even if the genus had so great a range in time, of which we have no evidence. I therefore refer this shell to the genus *Posidonomya*, to which it much more probably belongs, though its generic relations cannot be considered definitely settled until its hinge characters can be determined.

It will be observed that our figures represent a right and a left valve, that differ quite enough in form to belong to different species, but as they are opposite valves (of course not of the same individual), and such

shells often vary much in form, I prefer not to attempt to separate them specifically without knowing from the study of a series of specimens the extent to which this species varies. To prevent confusion, however, in case they may be found to belong to two distinct species, I would state that the form represented by fig. 7a is considered the type of the species here described.

Locality and position: In dark shales of the Coal Measures at Flint Ridge, Ohio. I think I have also seen imperfect specimens of the same shell from the Coal Measures of Illinois.

GENUS MACRODON, Lycett, 1845.

[Buckman in Murch. Geol. Chelt., 2d ed.]

MACRODON OBSOLETUS, Meek.

Plate 19, fig. 9.

Macrodon obsoletus, Meek (1871); List Carb. Fossils from West Virginia, 5 (Extr. from Rep. Regents University of West Virginia).

Shell (as determined from internal casts) transversely elongated sub-rhombic, rather compressed; hinge line nearly equaling the length of the valves; posterior margin compressed, obliquely truncated, and very slightly, so as to meet the hinge above at nearly a right angle, and subangular or very abruptly rounding into the base below; anterior margin intersecting the hinge at a right angle above, thence rounding downward into the base, which is not quite parallel to the dorsal margin and slightly sinuous near or a very little in advance of the middle; beaks depressed very nearly to the line of the dorsal margin, rather compressed, and placed about one-fourth the length of the hinge from the anterior extremity; surface showing a few distant concentric marks, traces of fine striae of growth, which are crossed on the posterior dorsal region by fine, rather closely arranged, radiating striae.

Length, 1.40 inches; height, 0.58 inch; convexity, about 0.22 inch.

The original type specimen of this species is only about two-thirds as large as that here figured, which latter is only a partly internal cast of a right valve. This cast shows the impressions of two or three elongated posterior hinge teeth, nearly parallel to the cardinal margin. In a cross light it also shows obscurely the fine, radiating and concentric striae of the posterior dorsal region, the former of which escaped the eye of the artist when drawing the figure. On this part of the type specimen these striae form a finely cancellated style of ornamentation.

At a first glance this shell recalls *Macrodon tenuistriatus*, M. and W., (Ill. Report, V., 576, pl. XXIII., figs. 4a, b), but it is a much larger, *decidedly* less gibbous shell, and appears to be entirely without the minute, crowded, radiating striae seen on the central and anterior portions of that species. This absence of radiating markings on its central and anterior portions will also distinguish it from *M. carbonarius* (= *Arca carbonaria*, Cox), Kentucky Geol. Rep., Atlas, pl. VIII., fig. 5), which has well defined radiating costae all over.

Locality and position: The original type specimens of this species were in the lower part of the Coal Measures in Monongahela county, West Virginia, while the specimen here figured came from the Coal Measures at Newark, Ohio. Rev. Mr. Hertzner's collection.

GENUS YOLDIA, Moller, 1842

(Kroyer's Nat. Tidsskr., IV., 91.)

YOLDIA STEVENSONI, Meek.

Plate 19, figs. 4a, b.

Yoldia Stevensoni, Meek (1871); List Carb. Foss. from West Virginia, 6 (Ext. from Rep. Regents University of West Virginia).

Shell much compressed, very thin, longitudinally elliptic-subovate, being about twice as long as high, with the widest part a little in advance of the middle; anterior margin narrowly rounded; posterior narrower and more compressed than the anterior; basal outline broadly semiovate, being a little more prominent anteriorly; cardinal border sharply carinated, and provided with a marginal furrow on each valve, slightly convex in outline anteriorly, and straight or a little concave behind the beaks; umbonal slopes not angular; beaks depressed and placed very slightly in advance of the middle. Surface ornamented by fine, regular, concentric lines, separated by wider furrows.

Length, 0.78 inch; height, 0.38 inch; convexity, 0.16 inch.

This is a very neat, remarkably compressed species, having exactly the form and external appearance of a true *Yoldia*, but its hinge and interior are unknown. The specific name was given in honor of Prof. John J. Stevenson, of New York, late of the University of West Virginia.

Locality and position: The figured specimen was from Monongahela county, West Virginia, found in a dark shale just below the Mahoning sandstone.

YOLDIA (PALÆONEILO?) CARBONARIA, Meek.

Plate 19, fig. 5.

Yoldia (Palæoneilo?) carbonaria, Meek (1871); List Carb. Foss. West Virginia, 6 (Ext. from Rep. Regents University of West Virginia).

This species is much more convex and elongated than the last, and has its beaks located farther forward, its anterior margin more narrowly rounded, and its posterior dorsal slope straighter and more declining. Its dorsal margin also wants the carinate and sulcate character of that shell, from which it also differs in having its posterior basal margin slightly sinuous, instead of regularly convex, and its surface without fine, regular, concentric striae.

Length, 0.84 inch; height, 0.38 inch.

The hinge and interior of this shell are unknown, but it has the external characters of form, etc., of some of the species included in the group *Palæoneilo*.

Locality and position Same as last.

GENUS SCHIZODUS, King, 1844.

(Ann. Mag. Nat. Hist., XIV., 313.)

SCHIZODUS CUNEATUS, Meek.

Plate 20, fig. 7.

Shell attaining a large size, ovate-subtrigonal, rather decidedly compressed, the greatest convexity being in the anterior and umbonal regions; anterior side very short, obliquely subtruncated above, and broadly rounded from near the beaks into the base; basal margin longitudinally semiovate, being most prominent anteriorly, somewhat straightened and ascending obliquely behind to the abruptly rounded or subangular posterior basal extremity; posterior side long, cuneate, somewhat narrowed, obliquely truncated above from the end of the hinge to the posterior basal extremity; hinge line straight behind the beaks, where it is about one-third as long as the valves and a little declining backward; beaks prominent, erect, incurved, and located only about one-fourth the entire length of the valves from the anterior margin; posterior umbonal slopes subangular near the beaks, and continued thence as a rounded prominence obliquely to the posterior basal extremity. Surface smooth, or only showing obscure lines of growth.

Length, 2.15 inches; height to top of beaks, 1.62 inches; convexity, 0.72 inch.

This fine species agrees in size and form, perhaps, more nearly with the well known European Permian species, *S. obscurus*, Sowerby, than with any other described species, though in some respects it is, perhaps, more nearly related to *S. truncatus*. It attains a considerably larger size, however, than even *S. obscurus*, from which it differs in having its beaks more elevated, and without any backward inclination. Its valves are also proportionally less convex, and have the anterior margin less prominently rounded in outline, while its posterior ventral margin shows not a trace of the sinuosity said to become more conspicuous in that species in large, mature specimens. In the latter character it differs still more decidedly from *S. Schotheimi*, of Geinitz, as well as in its less elongated, more inequilateral form, and higher beaks. Its much larger size, more compressed form, more elevated beaks, and shorter anterior side, distinguish it from *S. truncatus*, King.

I know of but two other American species that attain so large a size as this. These are *S. amplus*, M. and W., and *S. occidentalis* (= *Cypricardia occidentalis*, Swallow), both of which are from the Coal Measures. Compared with the former, it is at once distinguished by its much more elevated beaks, decidedly narrower and truncated posterior side, and sub-angular posterior umbonal slopes. In some of these characters it agrees more nearly with Prof. Swallow's species, while in other respects it differs far more widely, that shell being very much more ventricose, with a greatly more sloping posterior dorsal outline, less truncated posterior margin, and distinctly sinuous posterior basal margin, more angular posterior basal extremity, and more prominently rounded anterior basal outline.

I have before me, from the Upper Coal Measures at Nebraska City, Nebraska, a very similar form, differing only in its smaller size, more nearly central beaks, and much more prominent ventral and anterior margins. It is, however, probably a distinct species.

Locality and position: Putnam Hill and Flint Ridge, Ohio. Lower Coal Measures. Prof. Andrews's collection.

AVICULOPINNA AMERICANA, Meek.

Plate 20, fig. 2.

Avicula pinnaeformis, Geinitz (1866); Carbonif. und Dyas in Nebraska, 31, tab. II., fig. 13 (not *Avicula pinnaeformis*, Geinitz, 1857).

Aviculopinna Americana, Meek (1867); Am. Jour. Sci. and Arts, XLIV., 282, and (1872) Paleont. Eastern Nebraska, in Hayden's Report of Geol. Survey of Nebraska, 197.

Shell small, compressed, with the general form of a narrow *Pinna*; ventral margin ascending very gradually forward, and nearly or quite

straight, but rounding up behind, so as to connect with the hinge at right angles; dorsal margin very nearly straight, equaling the greatest length of the valves, and provided with a narrow marginal ridge; beaks very nearly obsolete, extremely oblique, and placed a little behind the narrow, obtusely pointed, anterior extremity. Surface with numerous concentric lines and lamellæ running parallel to the basal and posterior margins.

Length, 2.03 inches; height, 0.62 inch.

The only specimens of this shell that I have seen from the Ohio Coal Measures are all crushed perfectly flat between the laminae of shale, so as to obscure, to some extent, their characteristic features. The specimen figured seems to show the inside only of the right valve. It will be seen to be larger than the Nebraska type specimens of the species, and differs slightly in some of its details, but the latter differences are believed to be mainly due to the condition of the specimen, and the fact that it is probably the inner side that is seen.

That these little American Coal-Measure shells are entirely distinct from the European Permian species, *A. pinnæformis*, will, I think, be obvious enough without detailed comparisons. For remarks on this point, however, I would refer the reader to the Nebraska Report cited at the head of this description. Figures of the European form, for comparison, are also given there.

Locality and position: The original type specimens of this species was found in the Upper Coal Measures, at Nebraska City, Nebraska. It also occurs at near the same horizon in western Iowa, and at a somewhat lower horizon in the central region of that State. The Ohio specimen here figured came from the lower part of the Coal Measures.

GENUS PLEUROPHORUS, King, 1844.

(Ann. Mag. Nat. Hist., XIV., 313.)

PLEUROPHORUS TROPIDOPHORUS, Meek.

Plate 19, figs. 10a, b.

Shell transversely oblong, much compressed, with length a little greater than twice the height; posterior margin flattened and bifurcated, the lower truncation being nearly vertical, and the upper sloping obliquely downward and backward from the hinder end of the hinge; cardinal margin straight, equaling about two-thirds the length of the valves; anterior rounded below and sloping abruptly forward from the beaks

above; basal margin long, parallel to the hinge, nearly straight for most of its length, or faintly sinuous near the middle, rounding up anteriorly, and forming a more or less defined angle at its connection with the lower part of the posterior margin behind; posterior umbonal slope distinctly angular from the beaks to the angular posterior basal extremity, while a second carina passes obliquely backward and downward along the middle of the posterior dorsal space above the umbonal ridge of each valve; beaks depressed to the line of the cardinal margin, very little projecting, and placed one-fifth to one-fourth the length of the valves from the anterior margin. Surface marked by distinct concentric lines of growth, that become strongly defined on the flanks and anterior parts of the valves, but are less distinct on the space above and behind the umbonal angles.

Length, 1.10 inches; height, 0.52 inch; convexity, about 0.20 inch.

This shell has *very* much the form and general appearance of *Cypriocardia striato-lamellosa*, DeKoninck, as figured in his An. Foss. Carb., Belg., pl. H, figs. 8a, b, but its beaks are less prominent and not so curved forward, and it seems to be entirely destitute of the deep lunule seen in that shell. I have not seen its hinge, but one of the specimens (fig. 10b), which is partly an internal cast, shows the impression of a long, posterior, lateral tooth, and marks of a rather deep, anterior adductor muscle, as in *Pleurophorus*. Judging from the distinctness of the surface markings on the casts, it is probable that the shell itself is thin.

Locality and position: Coal Measures, at Newark, Ohio.

GENUS SOLENOMYA, Lamarck, 1818.

(Hist., V., 488.)

SOLENOMYA ?? ANODONTOIDES, Meek.

Plate 19, fig. 11.

Shell transversely elliptic-subovate, compressed, nearly twice as long as high, with the greatest height a little behind the middle; posterior margin nearly regularly rounded in outline; anterior extremity shorter and more narrowly rounded than the other; basal margin forming a broad, semioval or semielliptic curve, being generally slightly more prominent behind than in front of the middle; dorsal margin presenting a nearly straight, or very gently arched, outline from the beaks posteriorly, and rounding into the posterior margin behind, while in front of the beaks

it declines forward, with a straight or slightly sinuous outline above, and rounds into the narrowly rounded front below; beaks depressed to the line of the dorsal margin, rather compressed, and placed about one-third the length of the valves from the anterior end. Surface marked by concentric striæ and some ridges of growth.

Length, 1.40 inches; height, 0.74 inch.

I know nothing of the hinge and interior of this shell, and have, therefore, only referred it provisionally to the genus *Solenomya*. Possibly I should call it *Edmondia anodontoides*, though it is quite as probable that it will be found to belong to neither of these genera when its hinge characters can be seen.

Locality and position: From the Coal Measures, at Newark, Ohio.

GENUS ASTARTELLA, Hall, 1858.

(Geol. Report Iowa, I., part II, 715.)

ASTARTELLA NEWBERRYI, Meek.

Plate 19, fig. 3.

Compare *Astartella vera*, Hall (1858), ib., pl. 29, figs. 1a, b.

Shell of medium size, trapezoidal-subovate, being wider anteriorly, with height about three-fourths the length, rather convex; anterior margin rounded; base longitudinally semiovate, being more convex in outline anteriorly, and a little sinuous behind; posterior side narrowed, and nearly vertically truncated; dorsal margin sloping and nearly straight behind, declining more abruptly, with a more or less concave outline in front; beaks moderately prominent, located about one-third the length of the valves from the anterior margin; posterior umbonal slopes forming an obtuse ridge that extends obliquely backward and downward to the abruptly rounded posterior basal extremity; above this ridge the triangular posterior dorsal region is flattened and cuneate, while the flanks just in advance of it are a little concave. Surface ornamented by about twenty to twenty-five very regularly disposed, distinct, concentric, slender ridges, that are separated by wide, rounded furrows, in which traces of very fine lines of growth may be seen by the aid of a magnifier.

Length, 0.63 inch; height, 0.51 inch; convexity, about 0.24 inch.

Of this form I have seen but a single very perfect left valve, and that is so firmly and closely attached to the hard rock that its lunule and

escutcheon can not be clearly seen, though it is evident enough that they exist. In general appearance it strongly recalls certain forms of *Crasatella*. Compared with *Astartella vera*, Hall (Iowa Report, I., part 2, figs. 1a, b), it will be seen to differ in having its beaks decidedly less prominent, less tumid, and farther from the anterior margin, while its posterior dorsal outline is straighter, and its concentric ridges more numerous, more prominent, and more regularly arranged. In its surface markings it more nearly resembles *Astartella concentrica* (= *Nuculites concentricus*, Conrad, Jour. Acad. Nat. Sci., Philad., VIII., pl. 6, fig. 19, 1839), from the Coal Measures of western Pennsylvania, but it is a more depressed, elongated shell, with less elevated and less nearly terminal beaks. It is barely possible that our shell may be a variety of one or the other of the species with which I have compared it; but with the only means of forming an opinion on this point now at hand, I can but regard it as a distinct species from both.

I have seen a specimen in Dr. Hayden's collections, from near Virginia City, Montana, that I could not distinguish from this, though it came, with some other Coal-Measure fossils, from beds apparently of the age of the Chester limestone.

Locality and position: Newark, Ohio. From the Coal Measures.

ASTARTELLA VARICA, McChesney.

Plate 19, fig. 2.

Astartella varica, McChesney (1860); Descriptions of New Palæozoic Fossils, 55, and (1869) Trans. Chicago Acad. Sci., I., 42, pl. 2, fig. 7.

I merely refer this shell doubtfully to the above cited species, not having had an opportunity to compare it with authentic examples of that form. So far as can be determined, however, from Prof. McChesney's figure and description, it seems to agree quite closely with his species in outline, being only a little more depressed, yet its concentric ridges appear to be less sharply elevated, and it is possible that a direct comparison might show other differences.

Locality and position: Coal Measures, at Newark, Ohio.

ASTARTELLA (undetermined sp.).

Plate 19, fig. 1a, b.

I have been unable to decide in regard to the specific relations of this shell. At one time I thought it might be a variety of *A. vera*, Hall, but

it differs so decidedly from the type of that species in form that I think it can hardly belong to the same species. When the figure was prepared I had intended to make thorough comparisons with *A. vera*, but circumstances beyond my control have prevented this.

Locality and position: Same as last.

GENUS CYPRICARDINA, Hall, 1860.

(Palæont. N. Y., III., 266.)

CYPRICARDINA? CARBONARIA, Meek.

Plate 19, figs. 8a, b.

Cypricardina? carbonaria, Meek (1871); Proceed. Acad. Nat. Sci., Philad., XXIII., 163.

Shell small, longitudinally oval, less than twice as long as high, the widest (highest) part being under the posterior extremity of the hinge; rather gibbous, with usually a broad impression extending from the beaks obliquely backward and downward to the middle of the base of each valve; anterior side extremely short, or nearly obsolete, convex, and rounded; posterior side broader, more compressed or cuneate, with its upper edge straight and sloping obliquely backward to the regularly rounded posterior margin; base broadly and slightly sinuous in the middle, and rounding upward at the extremities; hinge line straight, between one half and two-thirds as long as the valves, ranging at an angle of about 25° with the oblique, longer axis of the shell, so as to meet the sloping upper edge of the posterior margin at a very obtuse but moderately well-defined angle, thus imparting to the somewhat compressed posterior dorsal region a very faintly alate appearance; beaks extremely oblique, depressed nearly to the dorsal margin, very nearly terminal, and scarcely projecting beyond the rounded outline of the anterior extremity. Surface ornamented by about fifteen to twenty exceedingly regular, well-defined, subimbricating, flattened, concentric ridges or undulations, that gradually become smaller and more closely approximating on the umbones.

Length of largest specimen seen, 0.55 inch; height at the posterior extremity of the hinge, 0.32 inch; convexity about 0.18 inch; length of hinge, about 0.30 inch.

This little shell has nearly exactly all the external characters of *Cypricardina* (*C. lamellosa*, Hall), as found in the Upper Silurian, excepting that its beaks are more nearly terminal, and its concentric markings or

ridges not quite so prominent, while I have seen no indications of the minute sculpturing of that species.

In regard to the hinge of the typical species of *Cypricardina* nothing is known. In the shell here described, however, one of the casts shows that it has a moderately well-developed hinge plate, with one linear tooth in one valve, and one or two in the other, running very nearly parallel to the cardinal margin along its entire length, and at the posterior end of the hinge one or two shorter linear teeth, parallel to and beneath the others, while at the anterior end there is, in the right valve, one very small, slightly oval tooth, fitting between two similar ones in the left valve. These little teeth are slightly compressed from above and below, and placed so as to range, with their longer axis, nearly parallel to the hinge margin. No cardinal area can be seen, though there may have been a very small, narrow one immediately between the beaks, as there is no cavity seen in the hinge for an internal cartilage. The muscular and pallial impressions are so faintly marked that no traces of them have been seen on the casts of the interior.

Until the hinge of the typical species of *Cypricardina* can be made out it is impossible to determine whether our shell belongs to that genus or not. I have the impression, however, that it probably belongs to a distinct Carboniferous group, nearly allied to the Silurian genus *Cypricardites* of Conrad, but differing in having its principal hinge teeth extending the entire length of the cardinal margin, with cardinal area nearly or quite obsolete, and anterior muscular impression very obscure. It also differs from the known species of Mr. Conrad's genus in having remarkably regular, prominent, imbricating, concentric ridges or laminae. *Arca squamosa*, *A. obscura*, and *A. faba*, DeKoninck, belong apparently to this group, and possibly also the form he has referred, in his work on the Carboniferous fossils of Belgium, to *A. cucullæ obtusa* of Phillips, though the latter approaches still more nearly the typical Silurian forms of *Cypricardites* in its hinge characters.

If *Cypricardina* shall be found to have a different hinge structure, I would propose for the group, including our shell, the name *Synopleura*, in allusion to its regular, concentric lamina or costæ of growth. It is possible, however, that this group may be thought too nearly allied to *Cypricardites* to stand as a full genus, in which case the name of our species would have to be written *Cypricardites (Synopleura) carbonaria*.

Locality and position: Newark, Ohio. Lower Coal Measures.

GENUS ALLORISMA, King, 1844.

(Ann. Mag. Nat. Hist., XIV., 316.)

ALLORISMA COSTATA, M. and W.

Plate 19, figs. 6a, b.

Allorisma costata, Meek and Worthen (1869); Proceed. Acad. Nat. Sci., Philad., XXI
171, and (1873) Report Geol. Survey of Illinois, V., 585, pl. 26, fig. 15.

Shell small, or under medium size, longitudinally oblong, or trapezoidal, with length a little more than twice the height, moderately convex in the central and umbonal regions; anterior margin short, closed and rounded; basal margin forming a long, semielliptic curve; posterior side compressed, apparently a little gaping, somewhat obliquely truncated above, and connecting with the base below, so as to form a more or less defined angle at the termination of the oblique, posterior umbonal carinæ; posterior dorsal region above the umbonal carinæ compressed; cardinal margin equaling more than half the length of the valves, nearly straight, and slightly inflected, so as to form a very narrow, obscurely defined false area or corselet; beaks rising a little above the cardinal margin, and located near the anterior end; lunule small but well defined, and lance-oval in form. Surface ornamented by very regular, sharply raised, concentric costæ, separated by wider, rounded furrows, and all ending very abruptly behind, at the equally angular umbonal carinæ.

Length, 0.63 inch; height, 0.32 inch; convexity, about 0.20 inch.

The specimen from which our figures were drawn is not quite so complete on the posterior margin as fig. 6a would indicate, this margin being a little broken, so that the figure does not give its exact original outline. The surface of the posterior dorsal region is also not in a condition to show the lines of growth as represented on the figures, while fig. 6b is defective in not showing the narrow, obscure corselet, which, however, is nearly obliterated in the specimen by compression.

On comparing the figures on plate 19 with that of the large, more nearly perfect typical specimen given on plate 26, Vol. V., of the Illinois Report, the latter will be seen to differ in having its posterior margin bitruncated, and a second oblique ridge on the compressed space above the umbonal angle. This difference, however, seems to be mainly, if not entirely, due to the imperfection and smaller size of the Ohio specimen, which, as above stated, has the posterior margin not entirely perfect in

outline. I think I can also see some traces of the oblique second angle on the compressed, posterior dorsal region, especially near the beaks, though this is so faintly marked as to have escaped the attention of the artist.

Locality and position: The original type specimen of this species was found near the base of the Illinois Coal Measures, in Warren county of that State. I have, however, seen it from the upper part of the Coal Measures in Illinois and western Iowa. The specimen here figured came from the Coal Measures at Greentown, Stark county, Ohio.

GASTEROPODA.

GENUS PLATYCERAS, Conrad, 1840.

(Prelim. Report Palæont. N. Y., 205.)

PLATYCERAS TORTUM, Meek.

Plate 20, figs. 1*a*, *b*, *c*.

Platyceras tortum, Meek (1871); Proceed. Acad. Nat. Sci., Philad., XXIII., 171.

Shell very thin, dextral, attaining about a medium size, in young specimens composed of about one and a half to two volutions, subglobose, these first turns being contiguous, rounded, and rapidly increasing in size, after which the next turn, which composes the larger part of the shell, becomes free, very oblique, and increases more gradually in size, thus making the entire outline very obliquely elongate-rhombic; body volution a little flattened on the upper slope, subangular above, and somewhat prominently rounded near or below the middle; aperture apparently oval-suborbicular; lip without sinuses. Surface non-plicate, and with only moderately distinct lines of growth.

Length, 1.36 inches; breadth, about 0.90 inch; breadth and length of aperture, each 0.70 inch.

I have long been familiar with casts of this shell in the collections of the Illinois Geological Survey, but had some doubts whether they might not be distorted internal casts of a *Macrocheilus*. The specimens from which the above description was made out, however, retain the thin shell, and show that it is a true *Platyceras*. Specifically it is more nearly allied to some of the non-plicated varieties of the New York Upper Silurian, *P. spirale*, than it is to any Carboniferous species known to me, though its first two volutions are more compactly coiled together.

Locality and position: Greentown, Stark county, Ohio. Coal Measures.

GENUS MACROCHEILUS, Phillips, 1841.

(Palæoz. Foss., 103.)

MACROCHEILUS KLIPPARTI, Meek.

Plate 20, figs. 6a, b, c.

Macrocheilus Klipparti, Meek (1872) ; Proceed. Acad. Nat. Sci., Philad., XXIV., 328.

Shell attaining a large size, elongate-subfusiform, the length being sometimes from two and a half to three times the breadth; spire pointed at the apex, forming about half the entire length, with its lateral slopes concave above and convex below; volutions six to eight or nine, the upper five or six being very compactly coiled, and forming comparatively but a small part of the entire shell, while those below suddenly increase in size much more rapidly than the others, particularly in the direction of the longer axis of the shell, and form most of its bulk, these larger turns in large, adult examples sometimes assuming together a sub-cylindrical outline; last or body whorl comparatively long, cylindrical, or more or less oval, and somewhat produced below; suture moderately distinct, almost transverse between the smaller upper turns, but becoming decidedly more oblique below; aperture comparatively small and narrow, apparently sub-rhombic in form and effuse below; inner lip much thickened all the way up; columella twisted, so as to form a single prominent fold below the middle of the aperture. Surface nearly smooth, or only showing very obscure lines of growth. Outer lip unknown.

Length of one of the largest, most elongated specimens, 2.23 inches; breadth, 0.87 inch; length of aperture, about 1 inch.

This fine species most nearly resembles *M. Newberryi* of Stevens, but may be readily distinguished by its form, the slopes of the upper part of its spire being distinctly concave and the lower part convex in outline, instead of being evenly and moderately convex all the way down. This peculiarity is caused by the sudden enlargement of the middle and lower volutions, and the greater obliquity of their spiral curve, while in *M. Newberryi* the volutions increase in size regularly, and have the same uniform, spiral curve from the apex throughout the whole length of the spire. Young examples of the form under consideration are proportionally shorter, the elongation being to a considerable extent produced by the obliquity and prolongation of the last two volutions. These less elongated, younger shells, however, will be distinguished from *M. Newberryi* by the concave slopes of their spire, and the greater proportional

breadth of their body volution. It is also a larger and more robust species than *M. Newberryi*.

As none of the specimens yet seen have the outer lip and lower part of the aperture entire, the form of the aperture can not be made out, and there may even be room for some little doubt whether or not it is, in perfect examples, narrowed and produced into a canal below. If this is the case, the name of the species should be *Solenicus Klipparti*, as it appears to present very nearly the other characters of the type of that group.

The specific name is given in honor of John H. Klippart, Esq., of Columbus, Ohio, Secretary of the State Board of Agriculture, who discovered the specimens from which the foregoing description was made out.

Locality and position: Near base of Coal Measures, near Somerset, Perry county, Ohio.

SYNOPSIS
OF THE
EXTINCT BATRACHIA FROM THE COAL MEASURES.

BY
EDWARD D. COPE.

PHILADELPHIA, *February 5, 1874.*

Prof. J. S. NEWBERRY, Director of the Geological Survey of Ohio :

SIR: I send, at your request, the report which I have prepared for the use of the Geological Survey of Ohio on the extinct air-breathing vertebrata of the Coal Measures of your State. Hoping that you may find it adapted to your purpose, and that the influence of your position will continue to advance this interesting department of palæontological science,

I remain, with respect,

EDWARD D. COPE.

EXTINCT BATRACHIA.

The first information we possess on this subject was furnished by Prof. Jeffries Wyman, who in March, 1857,* described two species of extinct animals which had been discovered in the Coal Measures, near Linton, by Chas. M. Wheatley, A.M. These he regarded as Batrachians, and observed that one, which he named *Raniceps lyellii*, appeared to possess characters of the *Anura* in the proportions of its cranium, while the vertebræ and fore limbs resembled those of the tailed division (*Urodela*). Another form was represented by very few portions of the skeleton, and differed from the last in its strong ribs. This he did not name, and it resembles the species called, in the present essay, *Molgophis macrurus*.

Prof. J. S. Newberry also made collections at the same locality, but it was not until 1867 that he announced before the American Association for the Advancement of Science that he had found forms allied to the genera *Uroconylus* and *Ophiderpeton*, of the Irish Coal Measures. The materials then collected were placed in the writer's hands in the following year, and furnished the basis for an investigation into the structure of our extinct *Batrachia*,† including, as they did, twelve species, many of them represented by numerous individual specimens. One of these had been already described by Prof. Jeffries Wyman as *Pelion lyellii*, both genus and species being peculiar to the locality. The remaining species were referred by the writer to four genera previously unknown, and to the genus *Dendroperpeton*, Owen, previously discovered by Dr. Dawson, in Nova Scotia.

Collections subsequently made under direction of Prof. Newberry have added very much to our knowledge of these most interesting forms. The present synopsis raises the number of species to thirty-four, which are referred to seventeen genera.

I. OSTEOLOGY OF THE EXTINCT BATRACHIA.

These genera present us with a variety of external forms similar to those known among the Reptilia; thus *Sauropleuræ* resembles a long-limbed lizard, and *Tuditænus* a short-limbed one. *Amphibænus*, found in

* See American Journal of Science and Arts.

† See Transactions American Philosoph. Soc., 1869, p. 12; Proceedings Academy Natural Sciences, 1868, p. 211; Trans. Amer. Philosoph. Society, April, 1874.

the Illinois coal-field,* is a still more stout and squat form. In *Ptyonius* and *Oestocephalus* we have very elongate types, but in *Phlegethontia*, and probably *Molgophis*, we have veritable Batrachian snakes; the *Phlegethontia linearis* resembling a whip-snake in its proportions. In some of the Labyrinthodonts of the Old World we see forms rivaling the Saurians in power of armature and protective shields. All of these forms have been found to be referable to the Batrachia in their agreement in the following characters:

Basis-cranii composed of a parasphenoid bone, which is developed in the periosteal membrane; two occipital condyles, one on each exoccipital bone; a large squamosal bone, covering the quadrate externally; stapes external; articular bone present; the atlas undivided, with single centrum; coracoid distinct from scapula; limbs, when present, composed of femur, ulna, and radius, and pes or manus.

There are six orders of this class, which do not differ so much in external features as the orders of Reptilia, but are, in composition of skeleton, circulatory system, etc., quite as distinct. These were fully defined by the writer in 1868,† but farther investigation has added other important characters, especially with regard to the composition of the posterior walls of the cranium. The orders may be separated in key form, as follows:

I. Supraoccipital and epiotic bones present; supratemporal bone roofing temporal fossa. *Stegocephali*.

II. No supraoccipital, epiotic present; a palatine arch, no temporal roof. *Proteida*.

III. No supraoccipital nor epiotic bones; frontal distinct; quadrate osseous; no maxillary nor palatine arch. *Trachystomata*.

Maxillary arch, no palatine. *Urodela*.

Both maxillary and palatine arches. *Gymnophiona*.

IV. No supraoccipital nor epiotic bones; frontal and parietal united; quadrate cartilaginous; caudal vertebræ connate. *Anura*.

In all Batrachians the vomer is double, and usually bears teeth; the premaxillary is single or double, and the teeth are never planted in deep alveoli. There are six orders, as follows:

TRACHYSTOMATA.

Caudal vertebræ and frontal bones distinct; inferior pelvic elements not confluent.

O.o, supraoccipitalia, maxillaria, prefrontalia, palatina, and pterygoidea

* See Geological Survey of Illinois, by A. H. Worthen, Vol. II., p. 136.

† Proceedings Philad. Acad., 1868, p. 211; Extinct Batrachia and Reptilia of North America, in Transactions Amer. Philos. Society, XIV., p. 4, 1869.

wanting; epiotic and squamosal not distinct; nasalia present; ethmoid composed of two lateral pieces, each forming part of palate; quadrate osseous; mandible toothless, with condyle for the quadrate; teeth pleurodont; no "postorbital and supratemporal bones"; first pair hæmal branchi-hyals distinct.

PROTEIDA.

Caudal vertebræ and frontal bones distinct; inferior pelvic elements not confluent.

O, o, supraoccipitalia, maxillaria, prefrontalia, and nasalia wanting; palatine and pterygoidea present; ethmoid a vertical plate on each side of the cerebral lobes; squamosal and epiotic present; quadrate osseous; mandible toothed; teeth pleurodont; hæmal branchi-hyals, first pair con-nate; no "postorbital and supratemporal bones."

FIG. 1.



Amphiuma means, profile of cranium (from Georgia): Pmx. premaxillary bone; N. nasal; Prf. pre-frontal; F. frontal; Pa. parietal; Mx. maxillary; E. ethmoid; Pro. prootic; Sq. squamosal; Exo. exoccipital; Pt. pterygoid; Q. quadrate; Sta. stapes, natural size.

URODELA.

Usual cranial bones present, but pterygoids reduced or wanting; quadratum osseous, covered by the squamosal; no "postorbital nor supratemporal bones"; no epiotic nor supraoccipital; caudal vertebræ and frontal bones distinct; ethmoid, a vertical plate on each side; mandible dentigerous; teeth pleurodont; inferior pelvic elements horizontal, in contact; no osseous pubis; ilium suspended to a sacral rib. (Mostly no quadrato-jugal.)

GYMNOPHIDIA.

Usual cranial bones present and distinct, including frontals and pterygoids; no supraoccipital nor epiotic; quadrate osseous; caudal vertebræ distinct; no "postorbital nor supratemporal bones"*; ethmoid annulus surrounding cerebral lobes; mandible dentigerous; teeth anchylosed by their bases.† (Quadrato-jugal present.)

* When the temporal fossa is overarched it is by expansion of the maxillary and quadrato-jugal. (Stannius says, "squama temporalis.")

† The teeth of Cœcilia are compressed, with a trenchant posterior edge, which is crenate after the manner of *Megalosaurus*, *Carcharias*, etc. Thus to the numerous genera of Saurians and Selachians possessing this character must be added a Batrachian.

STEGOCEPHALI.

The cranial elements distinct, including frontals and pterygoids, and adding "postorbitals and supratemporals," a supraoccipital and an epiotic; quadrate osseous, frequently (?always) supporting a squamosal; caudal vertebræ distinct; orbitosphenoids normal, ?ethmoid; inferior pelvic elements distinct; mandible dentigerous; teeth with anchylosed bases, or in shallow alveoli; proximate tarsals not elongate. (A quadrato-jugal.

FIG. 2.

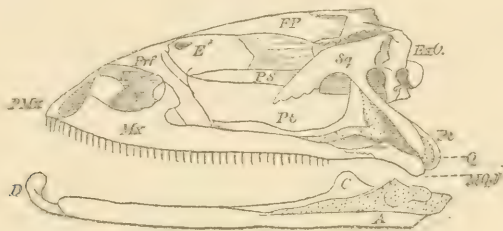


FIG. 3.

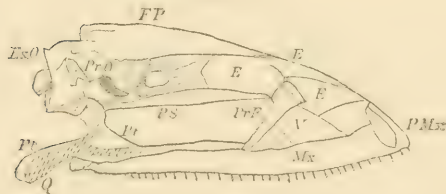


FIG. 4.



FIGS. 2, 3, and 4, *Rana Catesbyana*.—Fig. 2, side view of cranium; 3, the same, with squamosal, prefrontal, malar, and quadratojugal bones removed. Fig. 4, posterior view of the cranium—references as in fig. 1; FP, frontoparietal bone; V, vomer; PS, parasphenoid; A, angular; C, coronoid; D, dentary.

ANURA.

Frontal and parietal confluent, nasals wanting or rudimental; no epiotic nor supraoccipital; postorbital and supratemporal wanting: quadratum cartilaginous, covered by squamosal; ethmoid, an annulus (usually complete above) surrounding cerebral lobes; caudal vertebræ represented by an elongate, originally compound style; inferior elements of the pelvis

consolidated into a single vertical mass; ilium attached immediately to sacral vertebrae; proximal tarsal bones elongate.

The extinct genera belong for the greater part to the order *Stegocephali*. The order *Stegocephali* is evidently distinct from all others of the class. The supraoccipital bone is not present in any other order of Batrachia. The presence of the epiotic bone, which I have verified on a number of American genera, and which has been pointed out by European authors in genera discovered in that continent, is a character which is only shared by the order *Proteida*. In the *Trachystomata* the position of this element is occupied by a great backward prolongation of the protic, which is an exaggeration of the peculiar structure characteristic of the living Batrachia of the orders *Urodela* and *Anura*. The additional bones covering the temporal fossa, called by Owen the postorbital and supratemporals, do not exist in any of the other orders. None of the genera present any of the distinctive features of the *Anura*, unless, indeed the single genus *Pelion* have the united ulna and radius of the frogs, a point yet somewhat doubtful. With the *Urodela* the relations are closer, but the structure of the posterior part of the skull is here the same as that of the *Anura*. The same remarks will apply to the *Cæciliæ*, whose resemblances to the *Stegocephali* are superficial only. No forms certainly related to the *Trachystomata* have been discovered in any American formation, and one, the *Pulxosiren Brinertii*, Geinitz, has been found in Europe.

There are some relations to classes outside the *Batrachia* suggested by the osteology of this order. Thus the relations of the parietals, occipital and epiotic, are almost exactly those characteristic of many of the physostomous bony fishes, as *Cyprinidæ*, *Characinidæ*, *Amiidæ*, etc., or superficially, as in *Lepidosteidæ* and *Polypteridæ*, where the supraoccipital is represented by dermal ossifications. The relation to these forms is closer than to the *Dipnoi*. In the opposite direction a distant approach to the *Ichthyopterygia* may be observed in a few points. As in other reptiles, the occipital series of bones is complete in this order, but the epiotic is not well distinguished. The squamosal bone is produced downward on the quadrate more than in reptiles generally, thus resembling slightly the *Batrachia*, and the supratemporal, already described as peculiar to *Stegocephali* in their class, only exists among *Ichthyopterygia* among reptiles, and, as in the former, unites with a postorbital bone to form the supratemporal roof. The grooved teeth of the *Ichthyopterygia* may be considered in the same connection, as well as the extension of the squamosal over the deeply-inclosed quadrate bone in the *Crocodylia*.

The order *Stegocephali*, as here adopted, was proposed by the writer in

1868, and has since been occasionally employed by authors under the name of *Labyrinthodontia* (Owen). As then and now adopted, its scope is much more extended than that of the order proposed by Prof. Owen under the latter name, including as it does his order *Ganocephala* with it, as well as numerous forms discovered subsequent to Prof. Owen's classification, both in England and North America, to some of which the term *Microsauria* has been applied. As the labyrinthic character of the teeth does not appear in a number of the latter forms, and as the order as now defined by me is established on characters in large part not used by Prof. Owen, I retain the name given in 1868. It is probable that the *Labyrinthodontia* will be found to be a definable subdivision of this order, but with its characters we are as yet in a measure unacquainted. The nearest approach to the true Labyrinthodons seen in any American genus is found in the *Leptophractus* of the present essay.

II. THE CLASSIFICATION OF THE STEGOCEPHALI.

The classification of the *Stegocephali* presents many difficulties, which are mainly due to the character of the skeletons of these animals. Many of the bones are thin, and the sutures often squamosal. The composition of the skull is, on these accounts, often difficult to determine, especially as the specimens are generally injured by pressure, etc. I formerly arranged these animals in four orders, adopting from Prof. Owen the divisions *Labyrinthodontia* and *Ganocephala*, employing Prof. Dawson's term *Microsauria*, with modified definition, and adding a new one, the *Xenorhachia*. These divisions were based on characters mostly already in use, namely, the condition of the vertebral column as to ossification, the presence or absence of branchial bones, and the presence or absence of inflections of the enamel of the teeth. These characters I do not now regard as definitive of divisions of high grade, for the following reasons: There are genera, otherwise nearly allied, which differ in the degree of ossification of their vertebral columns, *e. g.*, *Sauropleuria* and *Colosteus*, *Pelion* and *Amphibamus*. It is uncertain whether all parts of the column are similarly ossified in the same species, *e. g.*, *Pelion Lyellii*. The presence of branchial hyal bones does not characterize genera with unossified vertebral column only, as *Archegosaurus*, but is evident in some of the osseous types, *e. g.*, *Oestocephalus*. The inflection of the investing enamel of the teeth, characteristic of *Labyrinthodon*, Owen, is well marked in *Leptophractus* of the Ohio fauna, but appears to be wanting in the teeth of some of the small species of other genera. Yet I am by no means sure that this is the case, as I observe it very clearly in the small species of *Ptyonius*. I do not find it well marked in *Oestocephalus*, and believe

that it may be found in various degrees of development in other genera, so as to be practically useless in discrimination of groups of high rank, at least until we are able to give it a more thorough investigation.

A number of groups may be discerned into which the genera fall, and which mostly present tangible structural characters.* The presence or absence of ribs is an important consideration. The presence or absence of limbs can generally be determined, although in some genera, as *Ptyonius*, they are very small. The extent of the vertebral column determines the habit of the animal in a marked manner. Two types of cranial form may be recognized; in the one it is lanciform, and composed of attenuated bones in which the sculpture is but little marked; in the other the skull is broad, obtuse, and flat, and strongly sculptured. The mere difference in the outline form of the head does not indicate family characters by itself, but in the present case each type is associated with other features, and future investigation will doubtless add to their weight. The divisions thus distinguished are the following, and I believe that they may be accorded family rank:

Family I. PHLEGETHONTIDÆ. Vertebral column very elongate, and without ribs; limbs probably wanting; cranium lanciform, of light construction. Genus *Phlegethontia*.

Family II. MOLGOPHIDÆ. Vertebral column elongate, furnished with ribs; limbs? wanting; cranium unknown. Genus *Molgophis*.

Family III. PTYONIIDÆ. Form moderately elongate; ribs present; limbs present, weak; cranium light, lanciform; belly protected by osseous rods. Genera, *Oestocephalus*, *Ptyonius*, *Hyphasma*, *Lepterpeton* (European).

Family IV. TUDITANIDÆ. Form lizard-like; limbs well developed; cranium broad and obtuse. Genera, *Tuditanus*, *Dendrerpeton*, *Hylonomus*, *Leptophractus*, *Ceraterpeton*, ? *Pelion*.

Family V. COLOSTEIDÆ. Form lizard-like; limbs present; belly covered with rhombic scutes; vertebrae often unossified. Genera, *Sauroplessura*, *Colosteus*, *Amphibamus*.

There are several genera whose position in relation to the above families can not be definitely determined at present. Such are *Pleuroptyx*, *Brachydictes*, *Thyrsideum*, and *Eurythorax*, in all of which some of the essential parts are wanting. The genus *Cocytinus*, so far as is ascertainable from a view of the inferior side of the skull, does not belong to the *Stegocephali*, but more probably to the *Proteida*.

With regard to generic characters, there are minor variations observ-

* See Transactions American Philosophical Society, April, 1874, where these are pointed out.

able in many portions of the skeleton. Most of the order exhibit three thoracic shields, but some species seem not to possess them, *e. g.*, those of the genus *Oestocephalus*. The same may be said of the osseous rods or scuta of the belly, which I can not find in the snake-like forms, and in a few others. The spines of the vertebræ may be enlarged and ornamented with sculpture, as in *Thyrsidium*, *Ptyonius*, and others. The genera in which no osseous vertebræ have yet been discovered are *Colosteus* and *Amphibamus*.

III. DISTRIBUTION OF THE STEGOCEPHALI IN TIME AND SPACE.

Species of this order have been discovered in all of the primary faunal regions of the earth excepting South America. In time they first appear in the Coal Measures, and continue through the Permian, the Rhætic, and the Trias. The first formation has yielded the greatest number of species, and the Trias is the next most productive of them. The following table is copied from the report of a committee of the British Association for the Advancement of Science, of which L. C. Miall is chairman, as expressing in a succinct manner the distribution of these animals in time and space. Additions and a slight correction appear in the North American department. The genus *Salamandrella*, Gaudry, is omitted, since its describer thinks that it belongs to the *Urodela*; for a similar reason the genus *Cocytinus* is omitted.

TABLE OF DISTRIBUTION.

	Carboniferous.	Permian.	Trias.	Rhætic and Jurassic.
G. Britain..	Anthracosaurus, <i>Hux.</i> Batrachiderpeton, <i>Hanc.</i> Loxomma, <i>Hux.</i> Ophiderpeton, <i>Hux.</i> Pholiderpeton, <i>Hux.</i> Pteroplax, <i>Hanc.</i> Urocordylus, <i>Hux.</i> Pholidogaster, <i>Hux.</i> Dolichosoma, <i>Hux.</i> Herpetocephalus, <i>Hux.</i> Ichthyerpeton, <i>Hux.</i> Ceraterpeton, <i>Hux.</i> Lepterpeton, <i>Hux.</i> Urocordylus, <i>Hux.</i>	Dasyceps, <i>Hux.</i> Lepidotosaurus, <i>Hanc.</i>	Labyrinthodon, <i>Owen.</i> Diadotognathus, <i>Miall.</i> Mastodonsaurus, <i>Jag.</i>	Debris (Il.).
Continent of Europe.	Apateon, <i>Von Meyer.</i> Archegosaurus, <i>Goldf.</i> Osteophorus, <i>Von Meyer.</i> Actinodon, <i>Gaud.</i>	Zygosaurus, <i>Eichw.</i>	Capitosaurus, <i>Munster.</i> Mastodonsaurus, <i>Jag.</i> Metopias, <i>Von Meyer.</i> Trematosaurus, <i>Braun.</i> Xestorhynchus, <i>Von M.</i> Chalcosaurus, <i>Von M.</i> Melosaurus, <i>Von M.</i>	Rhinosaurs, <i>Fisch. (Jur.).</i>
India.....			Brachyops, <i>Owen.</i> Goniolepis, <i>Hux.</i> Pachygonia, <i>Hux.</i>	
South Africa			Micropholis, <i>Hux.</i>	
Australia			Bothriceps, <i>Hux.</i>	
N. America.	Colosteus, <i>Cope.</i> Amphibaenus, <i>Cope.</i> Sauropleura, <i>Cope.</i> Pelion, <i>Wyman.</i> Ceraterpeton, <i>Hux.</i> Leptophractus, <i>Cope.</i> Eosaurus, <i>Marsh.</i> Baphetes, <i>Owen.</i> Dendrerpeton, <i>Owen.</i> Hylerpeton, <i>Owen.</i> Hylonomus, <i>Davidson.</i> Tuditanus, <i>Cope.</i> Hyphasma, <i>Cope.</i> Ptyonius, <i>Cope.</i> Oestocephalus, <i>Cope.</i> Molgophis, <i>Cope.</i> Phlegethontia, <i>Cope.</i> Pleuroptyx, <i>Cope.</i> Thyrsidium, <i>Cope.</i> Brachydectes, <i>Cope.</i> Eurythorax, <i>Cope.</i>		Eupelor, <i>Cope.</i> Dictyocephalus, <i>Leidz.</i> Pariostegus, <i>Cope.</i>	

As compared with the corresponding fauna of the Coal Measures of Great Britain, as exhibited in the writings of Huxley, Allman, Hancock and Arthey, Barkas and Miall, a number of points of resemblance can be detected. But in the first place, snake-like forms of the character of *Phlegethontia* have not been detected by the authors quoted, nor has the *Proteoid* type been described by them, as represented in our fauna by *Cocytinus*. On the other hand, the large types allied to *Labyrinthodon* are still unknown in America. But of Microsaurian genera there are a number of correspondences. *Oestocephalus* is represented by *Urocordylus*, and *Ptyonius* by *Lepterpeton*; *Dolichosoma* is similar to the former and to *Hyphasma*; *Colosteus* is our representative of *Archegosaurus*. *Ceraterpeton* is the only genus common to the two continents. It is worthy of remark that in the Ohio Batrachia the dermal defenses consist usually of slender rods, while in most of those of Great Britain these are replaced by rows of narrow scutella.

The locality from which these fossils were procured is near Linton, Columbiana county, Ohio, near Yellow Creek. The locality is thus near to the Pennsylvania State line and the Ohio River. They occur in a small basin near the middle of the series, in the lower part of the "diamond bed." This is eight feet in thickness, and the fossil Batrachia and fishes are found on the slate, which is in contact with the lower three to six inches of the seam, which is cannel coal.

It is to be observed that the specimens are in some cases quite obscure, and although little or nothing of a doubtful nature has been introduced into the following descriptions, yet the elements are sometimes covered by a thin layer of carbonaceous matter, which prevents their entire definition.

? PROTEIDA.

COCYTINUS, Cope.

Proceedings American Philosophical Society, 1871, p. 177.

Vertebræ and ribs osseous; anterior limbs, thoracic shields and abdominal armature apparently wanting; teeth on the premaxillary bone, none on the maxillary; hyoid elements largely developed, an axialhyal with basihyal on each side, closely united with the corresponding ceratohyal, at the end of which is an element in the position of a stylohyal; hæmal or basal branchihyals, three, the anterior two each supporting one pleural branchihyal and the third supporting one also, the first or anterior? hæmal branchihyal on the inner side of the ceratohyal, approaching the median line, and with elongate pleural element; urohyal not seen.

Such are the characters of a genus whose affinities are interesting but somewhat obscure. The hyoid apparatus is better developed than in any other here described, but it is by no means certain that it was branchiferous at maturity; nor does this character, on the other hand, render it certain that the animal is the larva of one of the other forms here described. The well ossified ribs and vertebræ are favorable, though not conclusive, evidence for adult age, while the structure of the hyoid apparatus is more like that of the gillless genera *Amphiuma* and *Protonopsis* than it is like the branchiferous genera *Siren* and *Necturus*, or the branchiate young of salamanders. Thus it differs from *Proteus* in the presence of the first axialhyal and the two first basihyals, and from this genus and *Necturus* in the possession of four distinct pleural branchihyals. In this it agrees with *Amphiuma*, as it does also with *Protonopsis*, in the three hæmal branchihyals.* *Siren* has only two of these elements, the first and second, without the third. As a consequence, in *Siren* the third and fourth pleural elements have no corresponding hæmal support, an arrangement totally different from that of *Cocytinus*. The arrangement in larval *Amblystoma* and *Triton* is quite similar to that in *Siren*, excepting that in *Triton* the small basihyals are present.

The question as to whether this genus was in life branchiferous or not is not easily decided, since the hyoid apparatus is about equally developed in the branchiferous genera *Siren* and *Necturus*, and the air-breathers *Amphiuma* and *Protonopsis*. Some considerations, however, point to an air-breathing type like the last two, though the individual may possibly have been immature. In the gill-bearing genera, as well as in the larvæ of *Amphystomæ*, *Tritons*, etc., the branchial arches approach nearest to archetypical perfection. Thus in the *Siren lacertina* (cut 5), two of the



OBSERVE COCYTINUS.

Pmx, premaxillary; *mx*, maxillary bone; *mi*, mandible; *ch*, axialhyal; *h'*, basal branchi-
hyal; *h''*, ceratohyal; *h'''*, sty-
lohyal; *bb*, hæmal branchi-
hyal; *b'*, *b''*, *b'''*, pleural branchi-
hyals.

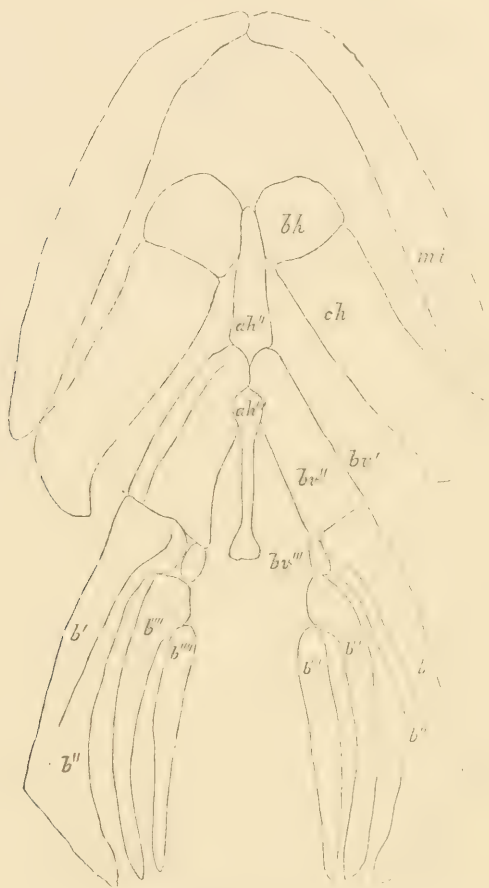


SIREN LACERTINA.

* For the nomenclature of these bones I follow Fischer, Ueber die Pemmibranchiaten und Derotremen, Hamburg, 1864.

four superior branchiarys, b, b'' , are supported by corresponding inferior or hæmal branchiarys, bv', bv'' , and these in turn are articulated each to its proper axialhyal, ah'', ah''' . The absent elements are the two axial and two hæmal elements, which exist as supports of the posterior two

FIG. 7.



NECTURUS MACULATUS.

superior branchiarys, b''', b'''' , in the fishes. In the branchiferous *Necturus maculatus* a considerable modification ensues. The four superior branchiarys are present, but according to Fischer the first and second are confluent, and are supported by confluent hæmal elements. (See fig. 6, $b' b''$ and $bv' bv''$.) A third inferior branchiary is added. If we now turn to the air-breathers, *Protonopsis* (fig. 7), we observe a marked peculiarity. The third hæmal branchiary remains, while the second is con-

fluent with the corresponding superior element, and the first is similarly confluent, or, as Fischer interprets it, the first branchiyl of the superior series extends to the axialhyal (fig. 7, *b'*). In *Muraonopsis* a greater divergence from the archetype exists. With all the peculiarities of *Protonopsis*, it further almost loses the second hæmal element, *bv''*, which appears at maturity as a process on the first pleural element.

FIG. 8.



PROTONOPSIS HORRIDA.

These characters may be tabulated as follows :

- A* Third hæmal branchiyl present.
- x* First and second hæmal branchiyls free and distinct..... *Cocytinus*.
- xx* First and second hæmals separate from each other, but confluent with their pleural elements..... *Protonopsis*.
Amphiuma.
- xxx* First and second distinct from pleurals, but united with each other... *Necturus*.
- AA* Third hæmal element wanting.
- x* Second hæmal element reaching the axis..... *Siren*.
- Larvæ, { *Amblystoma*,
 { *Triton*,
 { *Salamandra*.
- xx* Second hæmal element reduced, not reaching axis..... *Proteus*.

Now, it has been pointed out that *Cocytinus* agrees with the last named genera in the large development of the first pleural and hæmal branchiyls, and that it agrees with them both in the presence of the second and third hæmal elements. But these are more distinct than in either of those genera, and the third is larger and supports the fourth as well as its own pleural element. (Fig. 4, *bv''*, *bv'''*.)

The presence of the maxillary bone furthermore excludes this genus from near affinity to either the *Trachystomata* and *Proteida*, and allies it to *Amphiuma* and *Protonopsis*. It differs from both these genera in the absence of teeth from this bone as well as its apparently small development. This may indicate that the animal was not fully grown. In the hyoid region it differs from these in the apparent absence of the second axialhyal and in points of the hæmal segments. Thus the second is confluent either with the first or second pleural element in those genera, and the third hæmal element is much reduced and does not support the fourth pleural in either.

The present genus is, then, to be referred to the neighborhood of *Amphiuma* and *Protonopsis*, but forming the type of another family. The branchial apparatus is more archetypical or fish-like than in either of these in (1) the three distinct and well-developed hæmal branchi-hyals, (2) the four distinct pleural elements of the same, and (3) the distinct (?) stylohyal.

Its weak maxillaries have a larval aspect, but the ossification of all the bones, and the small size of the pleural branchi-hyals, as compared with the rest of the cranium, render it probable that the form is no more larval than the genera to whose neighborhood it is referred. That it passed a portion of its existence as an aquatic branchiferous animal is no less certain.

COCYTINUS GYRINOIDES, Cope.

Transac. Amer. Philos. Soc., 1874.

The only specimen of this Batrachian embraces the inferior bones of the cranium in a complete state of preservation, with the muzzle, with its teeth; also of the anterior eight vertebræ, with their ribs. The condition of the hyal elements is as follows: The hæmal element of the first branchial arch is partially concealed on both sides by the ceratohyal. An expanded truncate face of attachment to the axial element is visible on both sides, but the body of the bone is flat and presents the edge in the specimen. The first pleural element proceeds from just behind and within its extremity; it is longer than the other pleural elements. A slender bone is visible extending from the space between the ceratohyal and mandibular angle; it may, therefore, pertain to the suspensorium of the jaw as well as to that of the hyoid arch, or be squamosal as well as stylohyal. The second hæmal bone is slender, but with an enlarged axial extremity; that of the right side is not so well preserved as to be safely determined. The third hæmal elements are

the smallest, and originate immediately in front of the occipital condyles and diverge outwards and backwards. They are little curved, sub-cylindric, and slightly expanded at the extremities.

Of the pleural elements the first and second are little curved, and the first is marked by a pit or foramen on the under side near the distal end, which is clearly visible on both sides of the specimen. The third and fourth pleurals are more curved, and the outer ends slightly expanded and directed backwards.

The obverse of the specimen shows that the anterior axialhyal is wedge-shaped. The lateral basihyals are massive. The second hæmal branchiyl is dilated, fan-shaped distally, and supports two pleural elements. The muzzle projects over the lower jaw, and was rather broadly truncate. The premaxillary teeth are cylindric and six in number on each side. The maxillary bone is represented by a lamina at each lateral extremity of the premaxillary. The mandibular rami are very stout, as are also the ceratohyals. The vertebræ have possessed some apophyses, apparently keel-like diapophyses. The ribs are slightly curved.

Length of head and eight vertebræ, .0335 m.; of head, .0152; expanse of mandibular rami, .013; length of left ceratohyal, .0085

THYRSIDIUM, Cope.

Established on a species which presents its principal peculiarities in the structures of the vertebræ. Two specimens present inferior views of the spinal column, showing that the genus possesses, like *Siren*, enlarged diapophyses, but that they are peculiar in their fan-like form. They resemble slightly the caudals of *Ptyonius*, but are present on the dorsal vertebræ. Whether the latter possess ornamented neural spines the specimens do not indicate. The abdomen is protected by the usual hair-like rods arranged *en chevron*, the angle directed forwards. No indications of limbs can be discovered on the blocks.

Without the cranial bones the affinities of this genus can not be determined; while it may be allied to *Cocytinus*, the vertebræ of that form are without the peculiar diapophyses.

THYRSIDIUM FASCICULARE, Cope.

The best preserved example of this salamander includes nine vertebræ and the corresponding ventral armature. The centra, seen from below, are much contracted in their form, presenting an obtuse median

rib, which expands to the articular extremities. In one or two instances the latter are divided by fracture, and moderately concave form of the adjacent surfaces is evident. The diapophyses are of complex form, but the details are concealed by the prevalent thin layer of coal which invests them. An inferior prominence runs parallel to the centrum; outside of this the process is obscurely trilobate and thickened, not flattened, as in the caudal vertebræ of *Ptyonius*. Several ribs of moderate thickness appear by the side of the diapophyses. Eleven abdominal rods in .005 m.

Length of a ventrum, .007 m.; width of articular extremity of do., .004; total width of do., .013; length (antero-posterior) of a diapophysis, .005.

The second specimen was originally referred by me to the *Oestocephalus remex* as a posterior portion of its vertebral column, immediately preceding the caudal series. This reference appears to me to be incorrect, although the resemblance between the corresponding parts in the two genera is no doubt considerable, and the alternative of proposing a new genus and species was not at that time advisable. The specimen is pl. 21, fig. 2, and is described as follows: It is Nos. 26, 29, Mus. Newberry, a series of dorsal vertebræ that is without head or limbs. The vertebræ are elongate, three of them extending over 2.10 mm. The neural spines are longer than high, and are nearly in contact at their margins; each is marked by about five obtuse vertical ribs. A fractured section of the abdominal dermal spines in place displays at least six superimposed layers of them.

STEGOCEPHALI.

PHLEGETHONTIA, Cope.

Proceedings American Philosophical Society, 1871, 177.

This is one of the most interesting genera of the present series. It rests chiefly on a single specimen of one species, which is not perfect, but which displays the following characters: Head elongate-triangular; body and tail extremely elongate, the dorsal vertebræ without ribs, and the caudals without dilated spines; no vertebral armature nor limbs.

As a great portion of the length is presented, and no ventral rods or scales are visible, and as this character is confirmed by a second species, it probably belongs truly to the genus. The pectoral shields are also wanting in the specimen, but as there is a considerable vacuity behind

the skull of the specimen, it may be that these were lost with other parts. Chevron bones are not observable on the caudal vertebræ. This form is a true Batrachian snake.

PHLEGETHONTIA LINEARIS, Cope (species nova).

In the only specimen the dorsal vertebræ are much involved anteriorly, so that the length is not readily ascertained. The entire outline of the skull is preserved; it is elongate-triangular in form, with the angles of the mandibles produced backward, and the outlines of the rami a little convex. Nothing definite remains as to sculpture or dentition. The vertebræ have longitudinal diapophysial keels, and have a zig-zag interlocking of neural arches, probably by an external zygosphen above the zygapophyses. The latter are distinctly turned outward. The vertebræ are very numerous, and the tail very attenuated. The total length of the coils unwound is about .295 m., or eleven in eight lines; but there are interruptions not measured, and some confusion not unraveled. Number of dorsal vertebræ in .005 m., two; of distal caudals, three and a half; length of cranium, .022, width behind, .009. Its size is about that of the skull of *Ptyonius Marshii*, Cope. The slenderness of the body may be estimated from the diameter of the dorsal vertebræ, .0023 m., and of the caudals, .0014. The whole number of vertebræ preserved is fifty-six. Another specimen, embracing fifteen vertebræ, without processes, or ribs, or other parts, resembles this species. There is nothing additional to be learned from it.

PHLEGETHONTIA SERPENS, Cope (species nova).

This Batrachian is much larger than the last, approaching nearly in its dimensions the *Molgophis macrinus*. It is represented by a series of twenty-two vertebræ, which, like those of *P. linearis*, are devoid of ribs, abdominal armature, dilated neural spines, etc. The series, when complete, must have been very long, as there is little difference in size between the first and last of the twenty-two. They are marginate fore and aft, and much contracted medially, owing to the transverse expanse of the diapophyses. There may be, indeed, a diapophysial element beneath these, but if so, the two are undistinguishable. They are connected by longitudinal impressions, indicating the existence of the tendinous bands in the longitudinal muscles seen in *Amphiuma*, or the osseous spicules seen in the same situation in birds. The neural spines, as indicated by their narrow bases, occupy the length of the neural arch, and remind one of *Amphiuma*. Width of one of the vertebræ, three lines. This species appears to be rare at Linton.

MOLGOPHIS, Cope.

Proceed. Acad. Nat. Sciences, 1868, 220; Trans. Amer. Philos. Society, XIV., 20.

The characters of this genus are: body long, serpentine, without dermal armature, so far as known; vertebræ long and broad, with very prominent zygopophyses and moderate neural spines; ribs large, curved. No limbs or cranium can be ascribed with certainty to the type of this genus. The ribs are long, and though the head is not bifurcate, there appears to be both tubercle and head on the dilated extremity. Where crushed they display a large median vacuity.

This genus differs from *Ophiderpeton*, Huxley, in the characters of its dorsal vertebræ, which, in their projecting zygapophyses, resemble those of *Amphiuma*. The lack of ventral armature distinguishes it from *Oestocephalus*, while its well-developed ribs separate it from *Phlegethontia*.

MOLGOPHIS MACRURUS, Cope.

Loc. cit., Batrachian Reptile, Wyman, Amer. Jour. Sci. and Arts, 1858, p. II, fig. I.

This species is established by remains of two individuals, one embracing sixteen and the other fourteen vertebræ, with ribs. The neural arches, viewed from above, have a V-shaped outline posteriorly, from the fact that the broad zygapophyses meet on the median line and spread out distally over the broad anterior ones adjoining. The latter appear to be somewhat concave, and to border the former exteriorly as well as inferiorly. The base of the neural spine extends to the posterior emargination, but not quite to the anterior. The breadth of the dorsal vertebræ above is equal from the emargination behind to the anterior margin of the anterior zygapophysis.

The ribs are long for a Batrachian, but not long for a Reptile. They are well curved, chiefly near the proximal extremity. The longest I can find measured by a chord equals two vertebræ and two-fifths. Three vertebræ, measured along the median line above, equal eleven lines; one of these is 3.6 lines in width above. This animal has been, like *Amphiuma*, a snake-like Batrachian, but probably still larger. How near its affinities to this genus may be can not be ascertained, owing to the want of many important parts of the skeleton, but it differs in the important feature of the large, well-developed ribs. The size of the vertebræ would indicate a body of the size of the common rattle-snake (*Caudisoma horrida*), and too large for the *Brachydectes Newberryi*, which is only known from jaws.

MOLGOPHIS BREVICOSTATUS, Cope.

Represented by portions of the vertebral column of these and perhaps of other individuals obtained by Prof. Newberry during the first season of 1874. One of these includes nine pairs of ribs, with vertebræ, and another thirteen pairs. The vertebræ are subquadrate in section, and the concavity of the articular faces is not deep. They support strong lateral ridges separated by deep concavities. The heads of the ribs are somewhat contracted, and the shafts present outward a tubercular angle at a distance of one-fourth the length from the head. The remaining part of the shaft is stout, nearly straight, and gradually contracting to an obtuse extremity. They embrace a narrow medullary cavity. In none of the specimens is there any trace of abdominal armature, but abundant remains of the contents of the abdominal cavity, in proper position, are preserved on the blocks. This species is more massive than the *M. macrurus*, and the ribs are shorter, thicker, and less curved.

Length of seven vertebræ, .105 m.; length of one centrum, .016; diameter of the same vertically, .011; length of a rib on curve, .024; greatest thickness of the same, .0025.

The specimens exhibit imperfectly preserved neural spines, which are plain, and longer than high.

MOLGOPHIS WHEATLEYI, Cope (species nova).

Established on a specimen which exhibits about twenty-five vertebræ with ribs, and the posterior portion of the cranium. No traces of abdominal scales or rods, thoracic shields, or limbs are visible. By such negative characters it is referable to the genus *Molgophis*, although the definition of the latter is as yet incomplete. The present Batrachian may, indeed, be ultimately found to be an *Ophiderpeton*, to which it also bears resemblance.

The specimen is that of an animal of very much smaller size than the *M. macrurus*. The vertebræ are of moderate length, with a low neural spine, and centrum angular at the sides and truncate at the articular extremities when in place. The ribs are rather short, slightly curved, and apparently hollow. Although the vertebral centra are ossified, the elements of the cranium have a larval appearance. These consist of two parallel flat, bony plates, which resemble the frontoparietal bones of a frog; they are slightly separated from each other, but do not inclose a fontanelle. A wedge-shaped bone extends from the outside of the front of each of these, acuminate behind, and widening anteriorly in the position of a postfrontal bone. In front of the posterior border of each

?parietal, on its outer side, a bony enlargement arises, which contracts outward and forward into a narrow element which curves forward beneath the ?postfrontal. These look like an anteriorly directed quadrate with articular bone, such as are seen in larvæ and some adults of existing Batrachians. These determinations will require confirmation from additional material. In the meanwhile it is evident that the present specimen can not be referred to any of the other species herein described.

Total length of specimen, 0.0650 m. ; total length of a rib, .0050; total length of ?parietal and postfrontal bones, .0085; width of head at ?quadrate, .0080; length of a vertebra, .0020; depth of a vertebra, .0025.

This animal is dedicated to Charles M. Wheatley, A.M., of Phoenixville, Pennsylvania, one of the original investigators of the deposit in which it occurs.

PLEUROPTYX, Cope.

The specimens on which the species of this genus repose do not exhibit crania. The five—probably six—specimens which represent them offer various views of the vertebral column, and in none is there any trace of ventral or thoracic armature. Limbs can be ascribed to the genus with probability only. The vertebræ are of moderate length, with well-developed zygapophyses, and a short and not very elevated neural spine in the dorsal region, which is not sculptured in any way. The generic character is seen in the ribs. These are rather short and very stout, and support an ala on the posterior or convex border, which expands downwards, and then suddenly contracts to the shaft. The extremity of the latter is broad and truncate, and includes a medullary cavity, which is only partially fitted with cancellated tissue.

The general appearance of the species of *Pleuroptyx* is that of the *Molgophis*, so far as known, but nothing resembling the peculiar structure of the ribs is seen in any other.

PLEUROPTYX CLAVATUS, Cope.

Parts of two individuals express the typical characters of this species, while a third only differs in being considerably smaller. A fourth may very probably be referred here, and another, bearing several elements of a leg, should be most likely associated with the last mentioned.

The ribs are considerably narrowed near the head, and appear to possess a low tubercular process some distance below it. The shaft is curved

throughout; the laminar expansion is quite thin; while the distal end is expanded and concave, perhaps for the attachment of cartilage, although no trace of this remains on the shale. The neural spines have short bases, oblique anterior and nearly straight posterior borders, with obtuse extremity. I perceive no essential difference in the smaller specimen, which is one-third less than the types.

The limb is appropriate in its proportions to the present species, and may be described in this place. The first segment is one-third longer than the second, and has a transversely expanded head. The shaft is stout, the distal extremity not expanded and concave. The second segment is stout, more expanded proximally than distally, the proximal end truncate and slightly concave. A bone, much displaced, lies near it, and is probably ulna or fibula; it is as stout as the first, the end not expanded. Of metatarsals there are two, three-fifths the length of the second bone of the leg, and of phalanges two, of two digits each. The proximal are three-fourths the length of the metatarsals, and indicate elongate toes. The obverse of this specimen is preserved, and contains no additional toes or phalanges.

Length of a vertebral centrum, .014 m.; depth of a vertebral centrum, .009; depth of entire vertebra, .022; length of neural spine, .008; height of neural spine, .006; length of a rib on curve, .042; width of a rib at ala, .009; width of a rib at extremity, .005; length of first segment of leg, .038; length of second segment of leg, .024; length of metapodial bone, .010; length of first phalanx, .007.

CERATERPETON, Huxley.

The single example on which the American species of this genus is established is a dorsal view of the posterior part of the cranium, and the anterior part of the vertebral column. From this we learn that the genus is characterized by the possession of osseous vertebræ, with ribs, stout fore limbs, thoracic shields, and a cranium with sculptured surface. It also presents a remarkable development of the epiotic bone into a horn directed backwards, resembling in general that of *Ceraterpeton Galvanii*, Huxl. The number of digits can not be determined, nor is the existence of abdominal scuta or rods ascertainable. The ribs are not alate.

As compared with *Ceraterpeton Galvanii*, Huxl., this form presents no material difference; the absence of the abdominal scutella may be due to the dorsal view presented by the specimen, and be only apparent; in *C. Galvanii* they are quite minute.

CERATERPETON LINEOPUNCTATUM, Cope.

On the eleven or twelve vertebræ preserved the centra are longer than deep, but not slender; there are no sculptured spines. The ribs are not long, are rather stout, and beyond the proximal curve are nearly straight to the obtuse tips. The lateral thoracic shield is rather wide, and sculptured on its entire-external surface. The pattern is like that of the skull, and consists of delicate ridges radiating from the extero-posterior angle, and bifurcating in their courses towards the circumference; the interspaces are marked with a series of punctiform impressions. The epiotic horn is as long as three vertebræ, is more than four times as long as wide at the base, and has a gentle outward curvature, so that the sub-acute apex is turned slightly inwards. The supraoccipital has strongly convex lateral sutures. There are in the thoracic region some bones of tri-radiate form and striate surface, which probably belong to the scapular arch. The humerus is a stout bone, and the ulna and radius rather small and separate. Two phalanges are preserved; their whole number is unknown. A flat bone is preserved near the scapular arch, which has much the form of a lacertilian pubis, with anterior process, etc. The anterior part of the cranium is lost.

Length of thirteen vertebræ, .060 m.; length of a rib, .016; length of epiotic horn, .012; length of lateral thoracic plate, .012; width of lateral thoracic plate, .009; length of ulna, .008.

This horned salamander has been wanting heretofore to complete the representation of the Carboniferous forms of Great Britain in the corresponding fauna of the United States. It is about the size of the *Iguana tuberculata* of South America.

CERATERPETON LENNICORNE, Cope.

Represented by the remains of a cranium and its obverse in a good state of preservation. It is about as wide as long, and possesses the horns characteristic of this genus. The orbits are far anterior, and are well separated by a wide frontal bone. The impression of the latter is divided by a median line, which doubtless represents a suture. An oval plate appears above and behind each postorbital bone, and they are separated by a parallelogrammic area which represents either parietal bones or front parietals. Behind the oval plates two rather broad, band-like elements curve outwards and backwards, resembling the parieto-quadrato arch of lizards, or the pterotic elements of fishes. They are

directed towards the epiotics, which are produced into horns. The posterior lateral part of the skull is composed of a broad, shell-like element, probably the squamosal, whose surface is striate, with narrow raised lines. The entire temporal region is roofed in as in other *Stegocephali*, and the elements are to be identified with postorbital, supratemporal, quadrato-jugal, squamosal, and, perhaps, pterotic.

The muzzle is short and narrow. The surface of the skull, as indicated by a few remains of it, is marked with obscure and irregular ridges. The horns are slender, and directed straight backwards without incurvature. Their surface is finely striate-grooved; the outer face is excavated, and is separated from the superior by a longitudinal angle.

This species differs very much from the last in its sculpture and in the form of its horns. The specimen described is smaller than that of *C. lineopunctatum*.

Length of cranium without horns, .031 m.; length of a horn, .012; diameter of a horn at base, .0024; length of head on middle line, .026; width of head behind, .032; interorbital width, .007; length from occiput to orbits (axial), .0135.

PTYONIUS, Cope (genus novum).

Sauroplorea, part Cope; Proceed. Ac. N. Sci., Philad., 1868, 217.

Oestocephalus, part Cope; Trans. Am. Philos. Soc., XIV., p. 20.

Form elongate, with long tail and lanceolate cranium. Limbs weak, a posterior pair only discovered. Three pectoral shields present; abdomen protected by packed osseous rods, which are arranged *en chevron* the angle directed forwards. Neural and hæmal spines of caudal vertebrae expanded and fan-like. Ribs well developed.

This genus is the most abundantly represented by species and individuals among those found at Linton. These are almost snake-like in their proportions, and vary in length from three to ten inches. The muzzles of the known species are acuminate, and the upper surfaces of the cranium in the three spaces where it is preserved are sculptured by rather distant crests and tubercles. The squamosal is evidently more expanded than in recent *Batrachia*, either of the tailless or tailed orders. In *P. pectinatus* and *P. Vinchellianus* it is a broad plate concealing the quadrate, and apparently readily separable from it, as it is loose in some of the specimens. This is an interesting point, as the homology of the squamosal with the preoperculum of the fishes has been asserted by Parker and the writer,* and the view is confirmed by the resemblance

* See Proceedings American Ass. Adv. Sci., Vol. XIX., p. 222.

of the former to an operculum in these the most fish-like of the Batrachia. The teeth are numerous, small, and some of them apparently simple; others appear to be grooved. In a cranium (No. 140), perhaps of *P. pectinatus*, they extend to the tip of the slender jaws, are rather stout, acute, and evidently marked with a few strong grooves on the shank. The form of the head is a curious miniature of *Ichthyosaurus*.

Remains of limbs have only been observed in the position of the posterior pair, and that in several individuals.

The present genus resembles *Lepterpeton*, Huxl., of the Irish Coal Measures, in the form of the cranium and in proportions of body, but that exhibits divided abdominal rods, or "oat-shaped scales," and the caudal vertebræ have not the fan-like processes. In the last point they agree with *Urocordylus*, Huxl., but this genus is not represented as possessing ribs, and the abdominal rods are also divided, forming the "oat-shaped scales." I formerly referred the species of *Ptyonius* to *Oestoccephalus*, but in that genus no pectoral shields have been observed. The vertebræ in *O. remex* are of rather more elongate form than in the species of *Ptyonius*. Should, however, the pectoral plates be found in *O. remex*, this genus must be united with that one.

Four species have been detected by the Geological Survey:

- I. Vertebræ shorter; fan-like processes of caudal vertebræ broad, equilateral.
- x* Abdominal rods coarser, not more than ten in .005 m.
 Median pectoral shield discoid, radiate ridged; muzzle short.....*P. nummifer*.
 Median pectoral shield oval, pitted and ridged.....*P. Marshii*.
- xx* Abdominal rods hair-like, fifteen or more in .005 m.
 Middle pectoral shield with radii from the center, the principal forming a cross; form wider.....*P. Vincellianus*.
 Middle pectoral with pits at the center and few or no radii; form narrow.....*P. pectinatus*.
 Middle pectoral shield narrow, closely reticulate medially, and radiate towards the circumference; size half that of the last.....*P. serrula*.

PTYONIUS NUMMIFER, Cope.

Two well-preserved individuals display peculiarities which indicate specific distinctness from previously known species of *Ptyonius*. The abdominal rods are of the coarse type of those of the *P. Marshii*. The caudal fans are well developed, and not so wide as in *P. pectinatus*. The pectoral scuta form a discoid body of a different form from that of *P. Marshii*, and I can not detect the lateral scuta at all. The sculpture consists of strong ridges, which radiate from the center to near the border.

Immediately in front of this wide scutum is the head, which has a different form from that of the known species; although, viewed from above, it is relatively as well as absolutely the widest in the genus, the length being one-fifth less than the width behind, and the length of the muzzle exceeding that of the orbits by one-fourth. The interorbital width is two-thirds the long diameter of the orbit. The thinness of the cranial bones prevents a determination of the structure of the skull, but there is a flat, narrow bone in the position of ethmoid, and a scale-like plate behind and below the orbit.

The second specimen resembles the first in all essentials, including the abdominal rods and thoracic scuta. It displays a slender but rather elongate hind leg on each side, confirming again the definition of this genus as possessed of hind but not of fore limbs. The femur is larger than in other species, and is quite expanded proximately; one-half of the tibia remains.

Length to beginning of caudal fans, .065 m.; length of head, .015; do. to orbits, .006; do. of thoracic scuta, .007; width of thoracic scuta, .008; do. of abdominal armature, .008; length of a caudal fan, .0025; do. of a femur (No. 2), .0050; proximal width of do., .0015.

PTYONIUS MARSHII, Cope.

Colosteus Marshii; Trans. Amer. Philosophical Soc., XIV., p. 24.

This species is represented by the type specimen and by parts of three others, one of the latter including the pectoral shields. It is distinguished in the genus by the relatively large size of the dermal abdominal rods, which are stouter and less numerous than in the other species.

One specimen is lying on its back, displaying the ventral armature somewhat disturbed, and broken through in some places. The head is turned abruptly to one side, and is apparently right side up. Several of its elements are scattered on adjacent portions of the block.

The head is of an elongate lanceolate form. The upper surface of the frontal bones is punctate-rugose in relief, with short radii towards the margin. The distal two-thirds of the mandible is narrow wedge-shaped; the external surface is coarsely pitted. There are no teeth preserved. The sutures of the cranial bones are of the squamosal type, or fish-like.

The three thoracic shields are considerably displaced. The lateral are subtriangular, and are strongly ridged towards the inner margin. The median shield is short spatulate, the narrow portion directed anteriorly; the posterior rounded. It is coarsely pitted medially, and coarsely and

strongly radiate-ridged to the margin. Immediately behind these plates the dermal armature commences. It consists of elongate, narrow, sub-cylindric scales, which meet on the median line, converging anteriorly, as in the long rod-like pieces of *Oestocephalus*.

Nothing can be found pertaining to limbs; but some laminae and impressions in the position of pelvis, but not immediately connected with the other portions of the skeleton, may belong to the latter arch.

Length of body to buckler, 4.2 mm.; width of ventral armature, .8; impression of humerus (or coracoid), .2; length median thoracic plate, 1.15; width do., .51; length fragment under jaw, .75; depth do. at middle, .15; width end muzzle, .29.

In a second and smaller specimen the fan-shaped neural spines are seen to be developed in the dorsal region, though longer than high. The median pectoral plate is a broad oval, with a lanceolate prolongation in front. Behind it is subtruncate. Besides the radiating ribs, there are a few tubercles medially. The chevrons of the abdominal armature are separate from each other and continuous from end to end, thus not forming a zigzag median longitudinal suture, as in *Sauropleura longipes*, etc.

In another specimen the peculiar coarse ventral rods are associated with the anterior part of the caudal series of vertebrae, with their fan-shaped processes. The latter are about as broad as high, and have entire margins and four or five shallow longitudinal grooves. A femur, with tibia and fibula, projects from near the origin of the tail. They are small, the femur measuring two fans of two caudal vertebrae along their summits, or .004 m. The tibia and fibula are well separated.

Other specimens present only ventral ossicles.

PTYONIUS VINCHELLIANUS, Cope.

Oestocephalus Vinchellianus; Proceedings Amer. Philos. Soc., 1871, 177.

Represented by the opposite halves of a single specimen, which includes only the cranium and anterior half of the body. The fan-shaped neural spines commence but a short distance behind the line of the pectoral shields; they are low, and with a few coarse ridges; the margin entire. The abdominal rods are delicate and hair-like. The pectoral shield is an oval, with a few radiating crests, which originate at the center; in the areas between these there are a few scattered tubercles. The lateral shields are ridged near the margin.

The cranium is lanceolate in form, and the bones of the superior walls are marked with a few raised points and ridges. There is a thin bone,

which I have already alluded to as the squamosal or preoperculum, shaped like a right-angled triangle, separated from the outer posterior angle of the head, which exhibits a few similar marks.

Length of cranium, 0.020 m.; width of do., .008; length median pectoral plate, .0042.

This small species is of the size of *P. pectinatus*, and should be especially compared with it. In specimens of that species in which the cranium has the same size, the median pectoral plate is narrower and more prolonged longitudinally, and exhibits tubercles and a few ridges near the circumference, but no cross-like figure.

Dedicated to Prof. Alexander Winchell, of the University of Michigan, author of that interesting work, *Sketches of Creation*.

PTYONIUS PECTINATUS, Cope.

Sauroplessura pectinata, Cope; *Proceed. Acad. Nat. Sciences*, 1868, 216.

Oestocephalus pectinatus, Cope; *Transac. American Philos. Soc.*, XIV., p. 20.

Represented in the collections by eight characteristic and perhaps two other individual specimens. These furnish material for a pretty full account of it, though it is to be regretted that while two have the crania, the constitution of the superior face is not easily made out.

The head is lanciform, and the muzzle very elongate, slender, and acute at the extremity. The orbits are behind the middle of the length, and are large; they narrow the frontal region, so that it is narrower than the diameter of either. The cranium is truncate behind, and the angle of the mandible projects a little beyond it. The posterior portion of the mandible is strongly sculptured; on the upper half there are interrupted longitudinal ridges; on the lower the elevations predominate and inosculate, leaving intervening pits. The angle of the mandible is acuminate. In one specimen a bony plate in the position of the squamosal is striate in the direction of the axis of the head. The teeth are conic and acute, and some of them larger than the others and striate longitudinally. In one specimen a close series of minute conic teeth passes across the upper part of the orbit, indicating the existence of a palatine or pterygoid dentition. In one specimen the preserved surface of the bone which constitutes the postero-external cranial angle is sculptured with rather distant impressed pits. The thoracic shields are well preserved. The median is a narrow oval, with anterior and posterior prolongations. In one specimen it is marked by a limited number of tubercles, arranged radially round the vacant center; in another the

center is filled with tubercles also. There are few or no radii. The lateral shields are narrow, and are tubercular medially, and radiate near the margin. Abdominal rods bristle-like.

Vertebrae short. The expanded neural spines commence over the thoracic region, where they are low; they become well developed on the posterior dorsal region. The caudal fan-shaped spines are large, the neural and haemal similar and undistinguishable. The dilated portions form nearly equilateral triangles, which stand on moderately short pedicels. They are weakly ridged, and each ridge is prolonged into a narrow acute tooth beyond the margin, of which eleven may be counted on one of the best preserved spines. The longitudinal striae are terminated near the pedicel by two others which cross obliquely from each side, and meeting, present the appearance of the margin of a cup sculptured in relief, from which the striae arise. Pedicels smooth. The spines are in contact at their angles, thus forming a continuous line. In the typical specimen there are six in a half inch, in another seven, and in a third eight. A specimen originally described as belonging to this species, as having ten in a half inch, may belong to the *P. serrula*. The ribs are well developed and slender.

No traces of fore limbs can be found in any of the numerous well-preserved specimens; but in two of the specimens bones of the hind limbs are preserved. In one of these the femur is a small bone, contracted at the middle. Number of phalanges not preserved.

Extent of spines in largest, .097 m.; extent of spines in No. 2, .006; extent of spines in smallest, .005; length of head in smallest, .018; length from muzzle to femur of ditto, .0533; length of tail of ditto preserved, .037; length of femur ditto, .004.

The abdominal rods are bristle-like, and the vertebrae do not display any other processes than those described.

The most abundant of the Linton Batrachians.

Since the above was written several specimens display fully the attenuated muzzle of this species, with other characters. The mandible is very deep posteriorly, and the postorbito-squamosal and quadrato-jugal arches are evident. The orbit is large, the thoracic scuta small, and the abdominal rods fine.

Length of head, .016; length to orbit, .012; diameter of orbit, .004.

The teeth are very acute, rather remote, and their bases are plainly striate.

PTYONIUS SERRULA, Cope.

Proceedings Amer. Philos. Soc., 1871, p. 177. (*Oestocephalus*.)

Represented especially by a single almost complete specimen, and perhaps by another originally referred to the preceding animal. It is only half as large as the *P. pectinatus*, but displays a more complex sculpture of the pectoral shields, indicating that it is not immature. The tail is relatively longer.

The remains of the head indicate a trigonal outline, but the muzzle is lost. The pectoral shields are narrow and elongate, both median and lateral a little wider behind. The median has a considerable smooth anterior prolongation. Its surface is near the middle sharply reticulate-ridged, then closely radiate-ridged to the margin. The lateral shield is reticulate-ridged behind, and sends out radii, those on the anterior part subparallel. The triangular hæmal spines begin far forward; with the neurals they are rather elongate deltoid in form, without the distinct peduncle seen in *P. pectinatus*, but instead a short concave or crescent-shaped base, from the concavity of which the sculpture rises. This consists of ridges which extend beyond the intermediate spaces like teeth. Abdominal rods hair-like. Ribs distinct. Remains of limbs not discernible.

In the second specimen alluded to weak limbs are seen on each side of the posterior part of the abdominal cavity. On the right a moderately stout femur is given off, which is followed by a broken tibia and fibula, and then by five closely appressed metatarsals. The last are two and one-half times as long as the space between them and the femur; beyond them a few slender phalanges are moderately distinctly defined. The tibia is more distinct on the left, but no tarsus nor phalanges; but some of the metatarsals remain. Length of limb to end of metatarsals equal to five juxtaposed vertebræ, measured along the edges of the neural spines. The limb, especially the foot, is slender. In this specimen there are ten neural spines included in a length of half an inch.

In the typical specimen twelve neural spines are included in a half inch. The dorsal vertebræ are somewhat dislocated in the anterior region; nevertheless it appears that the length from the front of the pectoral shield is contained twice in the length of the tail; in the smallest example of *P. pectinatus* it enters the same .75 of a time, though perhaps a very little should be added for the missing extremity.

Length of type from anterior edge of pectoral shields, 0.085 m. ; length of median pectoral plate, 0.006 ; width of neural and hæmal spines at first caudal vertebræ, .0045 ; do. at middle of tail, .004.

OESTOCEPHALUS, Cope.

Proceed. Acad. Nat. Sci., Philada., 1868, p, 218 ; Transac. Amer. Philos. Soc., XIV., p. 16,

Sauroploera, pt. ; Proceed. Acad. Nat. Sci., Philada., 1868, p. 217 ; Proceed. Amer. Philos. Soc., 1871, p. 41.

Another genus resembling in its fan-like hæmal and neural spines of the tail the European form *Urocordylus*, and differing from it as *Ptyonius* does, *i. e.*, in the rod-like abdominal scales. Its form is long and snake-like, and it thus resembles *Ophiderpeton*, Huxl. But in the latter there are no limbs, and the cranium is very differently constructed ; in *Oestocephalus* it is much as in *Ptyonius* and *Lepterpeton*. The characters then are as follows :

Form slender and snake-like ; caudal vertebræ with dilated and sculptured neural and hæmal spines. Cranium lanceolate. Teeth numerous, of nearly equal size. No pectoral shields abdomen protected by very numerous bristle-like rods, which converge forward ; scales none. A pair of weak posterior limbs ; branchiæ bones present.

In the only well-preserved species the cephalic bones exhibit no sculpture from the parietal region forward. The angles of the mandibles are prolonged backward, as in *Apateon* and the *Anura*, and the well-developed ribs commence but a short distance behind the head. The vertebræ are slender and furnished with well-developed diapophyses. The neural spines of the dorsal vertebræ in *O. remex* are flattened and antero-posteriorly expanded and weakly grooved to their superior margin.

The character which separates this genus from *Ptyonius* is the absence of the three usual pectoral shields. In two specimens the pectoral region is presented, and no trace of the shield appears ; on the contrary, the ventral armature of bristles or rods extends to the head.

A pair of symmetrical bones, whose impressions are seen posterior to the occipital bone, I once thought might belong to rudimental limbs. They, however, appear to be the elements of the second or third branchial hæmal arch ; the first, or hæmal, followed by a second element, which is probably the inferior pleural segment of the arch. A third piece follows, which is the superior pleural element of the same. The other branchial arches are lost, but some impressions are visible.

Mr. Miall* finds that *Urocordylus*, Huxl., possesses ribs like this genus and hence suspects the identity of the two. The "oat-shaped scales" composing the ventral armature of *Urocordylus*, however, constitute an important distinctive feature. These are only found in two Ohioan genera, viz., *Sauropleura* and *Colosteus*.

Before I was fully acquainted with the structure in this genus, I referred some of the species to *Sauropleura*, which is quite distinct.

I am acquainted with one species from more or less completely preserved skeletons, with portions or wholes of crania, and another species from cranial specimens alone. They may be distinguished as follows:

I. Vertebrae elongate; fan-like caudal processes narrowed. Size large; mandibular teeth of unequal lengths, with the apices turned backward; *O. remex*.

II. Species only known from cranial bones with teeth. Teeth equal, erect, with acute conic apices, eleven in .005 m.; *O. rectidens*.

OESTOCEPHALUS REMEX, Cope.

Sauropleura remex, Cope; Proceed, Acad. Nat. Sci., 1868, p. 217.

Ib.; Proceed. Amer. Philos. Soc., 1871, p. 41.

Oestocephalus amphiuminus, Cope; Proceed. Acad. Nat. Sci., Philada., 1868, 218; Transactions Amer. Philos. Soc., XIV., p. 17.

This species is represented by nine specimens, generally with reverses, and three or more others are probably referable to it. Two specimens display crania, and one, caudal vertebrae complete, with hind foot; another consists of part of the caudal series, while most of the others are from the dorsal region. An instructive specimen represents the posterior portion of the abdomen, with basal region of the tail, with its fans, with its pelvic and limb bones.

They indicate an animal of the average size of the *Amphiuma means*.

The extremities of the vertebrae are deeply concave, but the centra are so long as to prevent the concavities entering more than one-fifth of the latter, each. The diapophyses are behind the middle, and are broad, curved backwards, and acuminate as in *Amphiuma*. The centra have a prominent median line below, with a longitudinal concavity on each side. Five of them a little exceed an inch in length. Neural spines moderate. The humerus is longer than the coracoid, and is considerably

* Report on the Labyrinthodontia of the British Coal Fields; Proceed. Brit. Ass. Adv. Science, 1873.

dilated distally; the coracoid slightly dilated at its superior extremity. The dermal armature commences immediately behind the head, and forms a band of fourteen lines in width; measuring across the spine-like scales, in a width of a line, four cylinders may be counted. The external portions are curved backwards, the interior nearly straight, those of the anterior series more delicate than the posterior.

The head is wedge-shaped, with regularly converging sides. The top of the cranium is somewhat broken in the specimen; the portions preserved are smooth, and the longitudinal suture is distinct for a considerable distance. The angle of the mandible is produced considerably behind the occiput, and is enlarged and rounded. The end of the muzzle is broken away, and the region of the orbits so fractured as to render their precise location uncertain. The superficial layer of the cranial bones is nowhere clearly visible, so that it can not be ascertained whether it is sculptured or not. The quadrate bone projects well posteriorly. Some fragments indicate small cylindric teeth, as in *Amphibamus*, but they are not characteristic.

Length of cranium without muzzle, 17.3 lines; width do. posteriorly, 11.5; length of the first hæmal branchial, 2.1; length second do., 2.5; length of sixth vertebra from skull, 3; extent diapophyses, 3.5; width centrum, 1.5.

The characters of the genus are further shown by a part of another individual in the same coal slate matrix. The cranium and anterior portion of the vertebral column only are preserved, the latter so much injured as to render the vertebral characters very obscure. As in the other, the bristle-like scales extend along the ventral region to near the cranium. The anterior two-fifths of the ventral side shows a large number of oval scale-like bodies, which belonged undoubtedly to the animal, and were probably dermal scales. They are, however, neither regular in form nor position. Close behind the head two or three long bones of the branchial arches have been exposed. They are slender and similar to those of the last specimen.

The cranium, though without the apex of the muzzle, shows its long wedge shape. The maxillary bone can not be distinguished, nor can the orbits be made out. One ramus mandibuli is pretty well preserved; it shows no coronoid process. Thirty-one teeth may be counted on a portion a little more than one-third its length. The anterior eleven of these are longer and stouter than the others. They are all, except a few most anterior, in pairs, *i. e.*, with a slight vacancy between every two.

The larger ones where broken at the bases exhibit a moderate pulp cavity; the smaller, a large one extending to near the tip. Several, though not all, of the larger teeth display a shallow groove on the external face to near the tip, which is probably owing to pressure and a partial crushing. The points of the larger teeth are more abruptly acute, and turned abruptly backwards. A portion of their increased length (.35) is to be attributed to the splitting off of the external dentary margin and the exposure of the roots. No alveoli are shown, and the dentition is probably by ankylosis of base.

A portion of the dentition is well displayed in a specimen (No. 117) which includes the top of the head without muzzle or occiput, with a portion of the side including both mandibular rami. One of these supports twenty-six or seven teeth, which are longest anterior to the middle, and diminish in both directions. A considerable number of maxillary teeth oppose them, while the rather shorter premaxillary teeth are curved towards the slightly posterior end of the dentary bone. All the teeth are uniformly cylindric, except at the extremity, where they are expanded and flattened so as to produce a longitudinal edge, which is carried backwards on a recurvature of the apex. The base is ankylosed equally and without enlargement, and no part of the shaft is striate or grooved. The upper surface of the cranium is narrow, a result not altogether due to pressure, with distinct median suture. The surface, with that of the mandible, is smooth, as in the cranium above described. The mandible exhibits two longitudinal series of foramina.

It is to be regretted that both the specimens of crania are in such a state as to preclude the proper determination of their elemental segments.

Length of mandibular dental series, 0.024 m.; depth of mandible at middle, .005; nine teeth in, .005; length of longer teeth, .002.

From the above it appears that the apparent abruptness in change from the longer to the shorter teeth in the skull first described is due to accident.

Characteristic of the species are the remarkable length and slenderness of the fan-shaped neural and hæmal spines, and the absence of an acute serration on their margins. In this species the spines have a laminiform expansion at the base in their plane. In the *Ptyonius pectinatus*, previously described, these spines are not only relatively broader and more fan-shaped, but they are acutely serrate on the margin and constricted at the base.

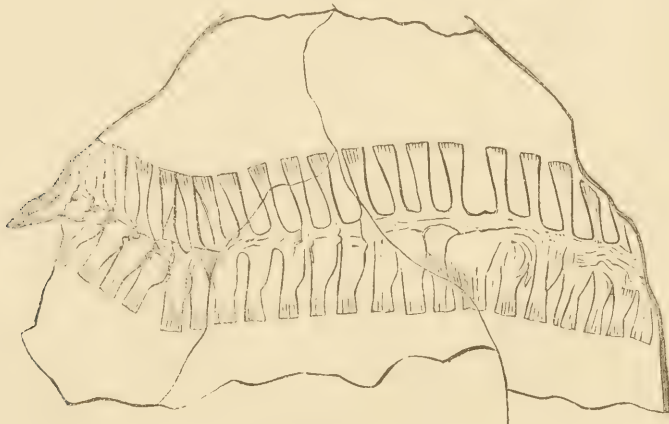
An interesting specimen displays the base of the tail, with two inches

of the preceding abdominal region, with pelvis, etc. The determinable portions of the last consist of a narrow bone, which is directed backwards and somewhat inwards on each side of the vertebral column. Its form resembles that of the ilium of *Protonopsis*, and is, like it, slightly expanded at the anterior end. It also resembles the corresponding element in *Sauroplorea longipes*, and in neither this species nor that can I find the segment or modified rib which connects it with the sacral vertebra in the existing genera of Salamanders. Towards the head of the femur it turns rather abruptly inwards, and it is possible that the latter portion represents the true ilium. In *S. longipes* the bone is straight, and on both sides extends to the head of the femur. The femur is rather short, nearly straight, contracted medially and expanded distally; the tibia is shorter and subcylindric. Beneath the ilium the last chevron of the abdominal rods appears, the outer extremities rising on the base of the tail. The caudal vertebrae are similar to those described below. The fans are elongate, truncate, and delicately lined.

Length of four proximal caudal vertebrae, 0.0175 m.; expanse of fans second do., .0185; length ilium (end broken), .0115; distal diameter do., .0030; length femur (both), .0115; distal diameter do., .0040 length tibia (both preserved), .0070.

Another specimen exhibits a length of 0.170 m., without indication of extremities or head.

FIG. 3.



CAUDAL VERTEBRÆ, NATURAL SIZE.

Besides one complete series, the caudal region is represented by a portion of the vertebral column three inches in length. In this space may be counted twenty-four vertebrae. Such of the latter whose outlines are

visible display centra characteristic of the genus; their terminal concavities conic, with apices meeting in the centrum, medially. The dilate hæmal spines are a little more than three times as broad distally as they are long, while the neural spines are a little narrower. The hæmal spines stand about the middle of the centrum. The basal half is furnished with an anterior ala, which leaves the anterior margin rather abruptly and extends to the next spine in advance. It returns gradually to the centrum, and is separated from the articular face of the latter by a notch. A similar ala exists on the posterior margin of the hæmal spine, which extends for a shorter distance above the base, and is narrower than the anterior. Each spine presents a median groove on its surface, which extends half way to the base or further; on each side of this are some three other grooves which extend but a short distance; surface otherwise smooth. The ends of the grooves slightly notch the truncated end of the spine.

The neural spines are on the posterior portions of the centra, and not in contact with the bases of those adjacent. They are without the dilatations of the hæmal spines, and are directed rather more obliquely backwards. They are similarly grooved, though without that so distinctly median seen in the hæmal series.

Both neural and hæmal spines become stronger towards the anterior part of the vertebral column. There appear to be no zygapophyses, nor diapophyses, nor rudiments of ribs. The centra are rather stout and somewhat constricted medially. There are no traces of dermal armature of any kind.

Length of a posterior centrum, 1.2 lines; depth of a posterior centrum, 1.0; length of hæmal spine of adjoining vertebra, 4.4; basal width, 1.4; median width, 0.9; distal width, 1.1; length of a more anterior hæmal spine, 4.3; distal width of a more anterior hæmal spine, 1.5; length of anterior neural spine, 4.0; width of anterior neural spine, 1.4.

In the specimen exhibiting the series from the hind limb to the extremity of the tail sixty-four vertebræ may be counted. The spines are similar in form to those just described. Distally the sides become more parallel, at first narrowing them, but near the tip they are short, and are wanting on the last vertebra. The centra support neural arches well interlocked by a double articulation. Thus the anterior zygapophysis, as usual, looks upwards, but the posterior, which rests on it, is in connection above with a zygasphen-like prolongation of the neural arch of the following vertebra. Thus the posterior zygapophysis fills a notch.

The posterior limb in this specimen is represented chiefly by metatarsals and phalanges, chiefly of one digit. There are in the latter four in.

place, terminating in a short obtuse ungual phalanx. Proximally to the first of the series is another, rather shorter than the latter, perhaps the first of the digit. Several other phalanges are irregularly distributed, and there are several metatarsals not well preserved. There were four or five digits.

Length of entire caudal series, 0.195 m.; width (total) at ninth, .021; width (total) at thirty-sixth, .02; length of four phalanges in place, .014.

The hind foot was evidently rather elongate, though its proximity to the vertebral column suggests that the proximal part of the limb was not so.

In size this species is about equal to the *Urocordylus Wandesfordii*, Huxl. The caudal spines differ in the greater attenuation of the neural series, and the presence of a basal lamina on the hæmal, judging from Huxley's account of the latter.

OESTOCEPHALUS RECTIDENS, Cope.

Transactions American Philosophical Society, April, 1874.

Indicated by a left dentary bone, with its teeth and external surface preserved. The latter is nearly smooth and without sculpture. The outer face is convex, and the general form is slender, but not curved upward at the extremity. Teeth straight and conic, apex acute; no visible grooves of the surface; eleven in .005 m., closely placed, and of equal lengths. The extremity of the dentary does not exhibit teeth, but they may be concealed.

Length of dentary, 0.022 m.; length of tooth line, .0152; depth of dentary at last tooth, .0027.

This represents a smaller animal than does the skull of *O. remex*, and differs much from the latter in the more closely placed and perfectly straight teeth.

I describe here a specimen which is closely related as to size with the *O. rectidens*, and is probably a member of this genus; but the specific reference will remain uncertain till other portions of the skeleton are discovered. Those preserved consist of twenty-five caudal vertebrae, probably from the anterior part of the column. There are, therefore, no ribs nor ventral armature. The centra are rather elongate and expanded at the extremities; the neural arches have a close union. There are no diapophyses, but the fan-shaped and striate neural and hæmal spines are present. They are, however, shorter than in *O. remex*, and not so exposed as in the species of *Ptyonius*. The bases are quite narrow. Their reduced size may be derived from the following measurements: Length of three centra, .0086 m.; extent of neural and hæmal spines, .0087.

The same dimensions in *O. remex* are .012; extent of spines, .02. While this species is smaller than the latter, it is larger than any known *Ptyonius*; its elongate vertebræ are most like those of *Oestocephalus*.

A cranium of a much smaller individual than any of the *O. remex*, found by Dr. Newberry in 1874, probably belongs to another species, but without other parts even the generic reference is uncertain. The great size, especially of the posterior part of the lower jaw, produces a marked resemblance of the toad to that of a diminutive crocodile. Length, .042; depth behind, .014; depth of lower jaw behind at coronoid, .006. (See pl. 44, fig. 3.)

HYPHASMA, Cope.

Proceed. Academy, Philada., 1875, p. 16.

Vertebræ osseous, the posterior dorsals, and probably the caudals, furnished with fan-like neural spines; limbs unknown—? wanting. Thoracic shields present. Ventral armature, consisting of rhomboidal scuta, forming packed rows arranged in chevrons, directed backwards, on top of which are the usual rod-like scales arranged in packed chevrons, with the angle directed forward.

The general appearance of the type of this genus is that of a *Ptyonius*, but the ventral armature is different from any thing observed in the known genera of this group. The larger external scuta are like those of the species of *Colosteus*, but their series have a different direction. The inner chevrons are those of many other genera.

HYPHASMA LAEVIS, Cope.

In the only known specimen the vertebræ have low and squarely truncate neural spines to near the head, and some distance anterior to the tail they are quite conspicuous and delicately line-grooved. The body is slender and probably limbless. The thoracic scuta are large and close to the head; the median is produced at both ends, but chiefly anteriorly, while the lateral are narrow; all are without sculpture. The head is seen from below. The mandibular rami are not so slender as in most species of *Ptyonius*, but are rather stout. They are a little incurved distally, so that the form of the muzzle is somewhat narrowed, but not produced. The teeth are not visible. Ten rows of the outer layer of scuta in .005 m.

Length of specimen, .068 m.; width of do., .008; length of seven vertebræ, .015; length of median thoracic scuta, .010; width of do., .004; width of lateral do., .002; length of mandibular ramus, .012.

Besides the generic characters, this species differs from any of the *Ptyonii* in the smoothness of the scuta, their relatively large size, and the anterior extension of the expanded neural spines.

BRACHYDECTES, Cope.

Proceed. Acad. Nat. Sci., Phila., 1868, 214; Trans. Am. Philos. Soc., 1868, XIV., p. 14.

This genus is indicated by two rami of a mandible and a portion of a premaxillary only. These, when compared with those of *Oestocephalus* and *Tuditonus*, from the same locality, and with others described by authors, are so much stouter, *i. e.*, shorter and more elevated, that they evidently belonged to a genus unlike either. The genus further differs from *Oestocephalus* in having the teeth of equal size to the posterior parts of the series, that is, to the base of the elevated coronoid process. The teeth are elongate cylindric cones, with their acute tips turned a little posteriorly. The fractured ones display a large pulp cavity. The three premaxillaries preserved are similar, but without curvature of the tips. They do not exhibit striæ or any other sculpture.

So far as the remains known go, the genus is nearer *Hylerpeton* than any other. According to Dawson, that genus is provided with a large canine-like tooth, at the anterior extremity of the maxillary, on the inner row, which is inserted into a distinct socket. No such tooth appears among those of this genus. The latter does not give any indication of the very elevated coronoid process of *Brachydectes*, though, the external portion of the dentary bone in that region being lost, little can be said about it.

BRACHYDECTES NEWBERRYI, Cope

Loc. cit., p. 14.

This species is represented by one nearly perfect ramus mandibuli, one dentary bone, and one premaxillary, probably not complete.

The dentary bone appears to have been attached by suture to the articular and angular, as its free margin has very much the outline of that suture in *Amphiuma* and lizards. The coronoid process would also seem to be a part of the same bone as in *Amphiuma* and *Menopoma*, and not composed of a coronoid bone as in lizards. It rises immediately behind the last tooth, and displays no suture.

The lower portion of the dentary is prolonged into an acute angle. This is separated by a deep and wide concavity from the superior poste-

rior prolongation, which is obtuse, and rises at once into the coronoid process. Teeth on this dentary, seven; the same number is on the preserved ramus; this number is suspected to be complete, or nearly so. The teeth terminate at the obvious termination of each ramus, which is, it is true, slightly obscured. These teeth are the longest of the *Microsauria* in relation to the depth of the ramus, equaling the largest in *Oestocephalus*. They are doubtless exposed, as are some of those of the last named genus, by the splitting away of the outer parapet of the dentary bone. As no traces of alveoli have been thus rendered visible, I suspect the dentition to have been acrodont, as in some existing Batrachia.

No external surface of the mandible remains, but there are no impressions of sculpture on the matrix. A little external face of the premaxillary displays none.

Preserved length of ramus (imperfect), 11 lines; depth at last tooth, 2; length of exposed tooth, 1.7; do. of dentary, 7.5; depth at coronoid, 3.5; do. at first tooth, 1.3.

In the mandibular ramus of the *Hylerpeton Dawsonii* there are, according to Prof. Owen, at least nine teeth; in the present species there are but seven. Prof. Owen's plate indicates a ramus whose depth at the last tooth enters eight and a half times the total length. In our species this depth enters about five times.

This species is dedicated to Prof. John S. Newberry, the able director of the Geological Survey of Ohio, and discoverer of most of the Batrachia herein described.

PELION, Wyman.

Proceed. Acad. Nat. Sci., Phila., 1868, p. 211; Trans. American Philos. Soc., 1869, 9. *Raniceps*, Wyman; Amer. Jour. Sci. and Arts, 1858, p. 158; not of Cuvier (*Pediculati*).

Three genera are here indicated as pertaining to a lacertiform type of *Stegocephali*. In one of these there are abdominal chevrons and no thoracic shields (*Sauropleuræ*); in another (*Tuditænus*) no abdominal chevrons and thoracic shields present. These genera are doubtless well defined, but one or the other of them may be identical with *Pelion*. The only specimen of the only species of the latter exhibits an inferior view of a portion of the skeleton; and the obverse, on which the thoracic and abdominal armor could have been preserved, has not come under my observation. The specimen, however, does not exhibit any ribs, although the vertebræ are well preserved; in the two genera above mentioned, well-developed ribs are presented.

As observed by Prof. Wyman, the genus presents some points of similarity to the *Anura*. The prolongation of the angles of the mandible is of this character, as well as the general form of the head. The bones of the fore-arm may be united as in frogs, and the length and curvature of the femur are seen among these animals rather than the Salamanders. The form of the femur is different from that of *Amphibamus grandiceps*, Cope, which also differs in the unossified condition of the vertebræ and presence of dermal scales.

PELION LYELLII, Wyman.

Raniceps Lyelli, Wyman, l. c.

The form of the head of this Batrachian is not unlike that of a frog or toad; it is as broad as long, and contracted forwards. The angles of the mandibles project considerably behind the posterior margin of the cranium, or that of the exoccipitals and parasphenoid; they present an interior expansion. The base of the cranium behind has the form seen in the frog, and is probably composed of the transverse processes of the parasphenoid and the pterygoid. The latter evidently diverge towards the maxillaries, in order to inclose large and posteriorly extending orbits. The mandibular rami are slender and curved, and in contrast with those of *Tuditanus punctulatus* and others. No palatine or vomerine teeth penetrate the carbonaceous layer that covers the under side of the cranium.

The vertebræ have the centra as broad as long, and medially somewhat contracted; diapophyses are not defined. Across the fifth vertebra a raised line extends, which may be the border of a scapula or other plate; across the ninth rests the head of the left humerus. The centra are more or less defined to the thirteenth, when they disappear; beyond this point there are indications of the continuation of the column, but so interrupted as to induce the belief that the centra are not ossified. The hind limbs are represented by the right femur and tibia.

The fore limbs are stout, and the humeri rather elongate. The latter are thickened proximally, and flattened and dilated distally. It is not absolutely certain, but highly probable, that the ulna and radius are proximally united, as in the *Anura*. The fore-arm of the left side is narrowed proximally, and expanded and notched distally; from the notch a groove extends to the proximal end of the distal two-thirds of the length. That of the right side is more expanded proximally, as though a flat view of the portion seen, perhaps on edge, on the left side.

The bone also expands distally, and is divided by a groove. The opposite halves of the respective ends are not continuous, and the bone is not much contracted medially, but probably broken. I do not think that the ulna and radius cross each other continuously (as represented in Prof. Wyman's figure at the page above quoted), although this is the only explanation of their position in the fossil, in case there are two elements. The other alternative is that they are confluent, in my opinion the more probable hypothesis.

The left hand exhibits four digits, of which the third from the inner is the longest. The number of the phalanges is 2, 3, 4?; the last of the third digit inferential; the fourth digit is imperfect. The carpus is not osseous. The ungual phalanx of the first digit is narrow, of the second enlarged at the end (perhaps a side view). The femur is longer than the humerus, and slightly curved, the shaft presenting an angle along its inferior aspect, the distal end a little expanded and truncate. The lower leg is represented by but one bone, which is elongate, with sub-cylindric shaft and expanded truncate proximal end. There is no hind foot preserved.

Length of cranium (median), 0.025 m.; do. do. oblique from angular bone, .033; greatest width of cranium, .033; length of five anterior vertebræ, .012; do. of humerus, .018; do. of fore-arm, .0113; do. of digit No. 1, .0120; do. of digit No. 2, .0145; do. of digit No. 3, .0195; do. of vertebral column preserved, .045; do. of femur, .023; width of vertebral centrum, .0025; do. of end of humerus, .0065; do. of end of femur, .0077.

The specimen described is the typical and only one known. Besides generic characters, the present species differs from the *Amphibamus grandiceps*, Cope, in the relatively larger limbs, and especially relatively longer hind limbs.

TUDITANUS, Cope.

Proceedings American Philosophical Society, 1871, 177.

Cranium broad, flat, orbits anterior, bones more or less sculptured. Teeth on premaxillary and maxillary bones of nearly equal sizes. Three pectoral shields sculptured externally. Form lizard-like; two pairs of limbs of medium proportions.

This genus is established on two species, of which the collection contains nearly entire specimens. In these no chevron abdominal rods or scales can be discovered, and it is not probable that they exist. The presence of the pectoral shield distinguishes this genus from *Dendrerpeton*,

Owen, while the thoracic plates and lack of ventral scuta separate it from *Sauropleura*. The plates may, however, be found in the latter; should the scuta be found in *Tuditonus*, which is not probable, these genera must be united. I associate with the *T. punctulatus* and *T. brevirostris* three other species, known only from crania, a reference to be finally criticized when more is known of them. They are all evidently allied. The largest is *T. radiatus*, named from elevated radiating ridges of the cranial sculpture; *T. mordax* has a strongly sculptured cranium, and large premaxillary teeth, while in *T. obtusus* the orbits are less anterior, and the teeth small. I formerly described it as a *Dendrerpeton*.

TUDITANUS PUNCTULATUS, Cope.

Transactions American Philosophical Society, April, 1874.

This Amphibian is known from a single individual well preserved on the opposite halves of a block of slate. The head, fore limbs, and twenty-three consecutive vertebræ, with ribs, are well defined, but of pelvis and hind limbs nothing is visible.

The cranium is less expanded posteriorly than in the other species referred to the genus, and has a triangular outline, with narrowed but obtuse muzzle. If I do not mistake the outline of the left orbit, it is near the transverse line which divides the head equally. The surface of a considerable portion is preserved, and is sculptured by small pits placed closely, the intervals in a very few parts assuming the form of ridges. The sculpture is thus more minute than in any other species. The under jaw of the right side is partially preserved, and displays longitudinal grooves. The ramus is stout and straight, and approaches the form seen in *Brachydectes Newberryi*. Its teeth are not preserved, but the extremities of the opposing maxillaries remain. They are small and acutely conic; both they and the ramus are much less robust than in the above mentioned species, and the enamel preserved is smooth.

The three *pectoral shields* are preserved, and as the exposed surface is the interior, it is smooth. The laterals resemble imperfectly spherical triangles. The outer margin is thin and convex, and the anterior angle curves round the apex of the median shield and joins that of the opposite side, forming a coarse interlocking suture. The median scuta is formed like some of the patterns of ancient mirrors. It is a wide oval excavated on each side behind, and produced from between these concavities into a long, flat, sternum-like process. The latter thus resembles the xiphisternal production of frogs and of some lizards: as in the former the ribs, having no hæmal elements, have no connection with it. Its extremity is simple and obtuse.

The *humerus* originates at the outer posterior angle of the lateral thoracic scutum. It is relatively as large as that of a frog, is contracted medially, and much expanded distally. It is followed at a short interval by a shorter ulna, which is also expanded at the ends and contracted at the middle. Then succeed numerous well-developed phalanges, which are so scattered as to render it impossible to ascertain the number that compose the digits, and how many of the latter existed.

The *vertebræ* are osseous and with slightly concave extremities on a lateral view; they are subquadrate in outline; their spines are not distinguishable. There are twenty-two to twenty-three pairs of osseous ribs, which are slender, rather short, and strongly curved backwards.

Length of specimen as preserved, 0.097 m.; do. of head, .024; width of head posteriorly, .020; depth of ramus mandibuli, .004; eight apices of teeth cover, .005; length of twenty-three *vertebræ*, .062; length of median pectoral scuta, 0.010; width do., .005; width of the three scuta, .010; length of process of median scuta, .005; length of humerus, .009; width do., .004; length of ulna, .006; width do., .002; length of phalanx, .003; expanse of longest ribs, .015; length of a long rib, .009.

Besides the generic characters already pointed out, this species differs from the *Tuditonus longipes*, to which it has some resemblance, in the much shorter fore limbs and shorter vertebral column in the anterior region of the body.

TUDITANUS BREVIROSTRIS, Cope.

Transactions American Philosophical Society, April, 1874.

Represented by two individuals, and probably by part of a third. Those with the cranium show that this part is large in comparison with the size of the body, and is as wide as long, with broadly rounded muzzle. The orbits are large, and situated for the greater part in front of a line marking the anterior third of the length of the head. The bones of the head are coarsely sculptured with radiating ridges and with some tubercles posteriorly; the supratemporal exhibits radii which extend outwards. The teeth are in two rows on that part of the maxillary arch anterior to the orbits; they are of equal sizes; the outer row appears to be directed more obliquely outwards than the inner. The former number five in .002 m. The thoracic shields are rather large, and have coarse radiating ridges.

Vertebral centra and arches are not well distinguished in two individuals, but, instead, an axial mass, which may represent *chorda dorsalis*. In one, three diapophyses are distinctly developed at the sacral region.

In a third individual, without head or thoracic region, but in which the ribs and hind limb are similar, as well as the general proportions, the vertebræ are distinctly ossified, but its reference to this species is uncertain.

Remains of both fore and hind limbs are preserved. They are rather stout, not large, and with short phalanges. The number of these is not distinguishable.

Length of femur No. 1, 0.060 m.; length of tibia and fibula No. 1, .050; length of anterior phalanx No. 1, obverse, .0285; length of femur No. 2, .060; length of tibia and fibula No. 2, .070; length of femur No. 3, .052; length of posterior phalanx, .026.

The deficiency of length of the tibia in No. 1 is probably due to imperfection of the specimen. There are bones of the fore limb in No. 2 which are not determinable. The ribs are rather long and little curved. The caudal extremity is not complete, but was evidently well developed.

Length from head to femur, 0.0356 m.; length of head, .0154; width do. behind, .0175; width do. interorbital, .0042; length of orbit, .0040.

TUDITANUS RADIATUS, Cope.

Transactions American Philosophical Society, April, 1874.

Represented by crania of several individuals, one of which is nearly perfect, and is selected for description; others are more or less complete, and present the prominent peculiarities of the species.

The marked character of this form is seen in the very anterior position of the orbits and contraction of the muzzle. The orbits are large and separated by a little more than their own diameter; their posterior border is in front of a line measuring the anterior third of the length to the supraoccipital crest, and nearly at the line marking the fourth of the length to the quadrate region. The posterior outline of the skull is deeply concave, the quadrate angle projecting beyond the occipital condyles, which are themselves quite prominent. The osseous segments composing the cranium are from the orbital region posteriorly, three median and four lateral on each side. The supraoccipital is rather small, and is broader than long. Its posterior border is straight, as are the short lateral margins. The anterior suture presents an obtuse angle forwards. A large rhombic plate occupies the parietal region, which is probably divided longitudinally by a suture, and represents the parietal bones. It extends, narrowing, nearly to the orbits, where the middle line is occupied by the much smaller frontal. The suture between the two is obscure, but seems to form an emargination of the parietals. There is a subtriangular postfrontal which expands posteriorly, and is suc-

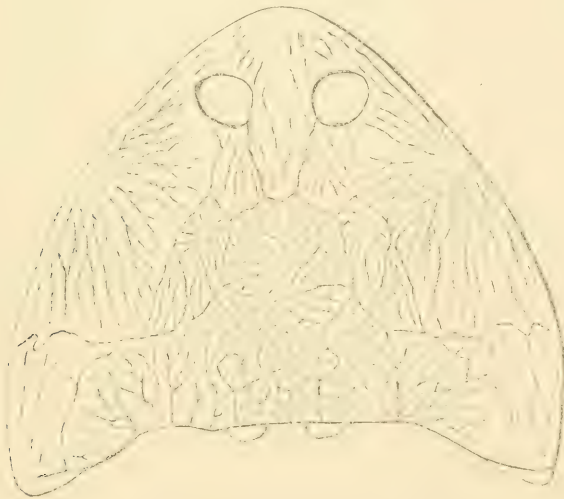
ceeded by a supratemporal which narrows and becomes acute posteriorly, being wedged between the parietal and what may be an anterior production of the plate representing the epiotic. A very large jugal plate extends from the orbits two-thirds the distance to the extremity of the quadrate, the remaining third being covered by a quadrato-jugal. After the jugal, the epiotic is the largest of the cranial shields or bones, and sends a prolongation forward between the parietal and supratemporal, as well as on the outer side of the latter. The accompanying cut explains the relations of these bones.

There is no trace of mucous canals. The sculpture consists of strong ridges radiating and inosculating. Radiation is more uninterrupted on both jugal, supratemporal, and anterior part of epiotic; in the first they originate in front of the middle exteriorly; on the supratemporal near the anterior part. The inosculation is honeycomb-like on the parietal, supraoccipital, and posterior parts of epiotic.

Length to middle of supraoccipital, .055 m.; do. to angle of quadrate, .0711; width at do. do., .069; do. at orbits (approximate), .031; interorbital width, .0085. (See pl. 27, fig. 1.)

No teeth are preserved with this cranium. The second specimen exhibits nothing more distinctly than the one described.

FIG. 10.



TUDITANUS RADIATUS, COPE, (CRANIUM RESTORED).¹

TUDITANUS MORDAX, Cope (species nova).

Represented by a partially complete cranium and some other fragments.

The muzzle is broadly rounded, as in *T. obtusa*, and the premaxillary teeth are relatively much larger. The bones are sculptured with delicate, acute, radiating, and inosculating ridges. The maxillary bone is preserved for the length of one inch; its teeth are smaller than those of the premaxillary bone; I count four in a line, which have a simple conic crown. The external surface of the maxillary is not very strongly sculptured. The orbits and nares are not well defined in the specimen.

TUDITANUS OBTUSUS, Cope.

Proceed. Acad. Nat. Sciences, Philad., 1868, 213; Transac. American Philos. Soc., XIV., p. 12.

This species is known by two partially preserved crania. The superior surface is exposed, the outlines of the jaws and orbits are well preserved, with the occipital condyles. The os quadratum is directed obliquely backwards, and the angle of the mandible extends to a line a little behind that of the occipital condyles. The zygomatic arch exists in a position similar to that in which it may be seen in a few genera of *Anura*, as *Discoglossus* and *Pelobates*. It extends downwards and forwards from the suprasquamosal to the maxillary region, but whether it is homologically squamosal or malar the specimen does not show. The postorbital is present as well, and with the last, and the supratemporal, forms the

FIG. 11.



bony roof of the temporal fossa. A piece which may be the pre and post-frontals combined, borders the inner superior margin of the orbit; it widens posteriorly, where it has contact with the parietal, etc., and narrows in front. Supraoccipitals form together a broad triangle on the upper plane of the cranium, of less extent than the adjoining supratemporal. These elements are pitted, and towards their margins radiate grooved.

The general form of skull is elongate behind, and much shortened in front of the orbits. The orbits are thus in front of a line equally dividing the cranium transversely, while in the *Dendrerpeton acadianum* they

are in the middle of the skull. The outline of the muzzle in our species is then broad, rounded, as in the *Menopoma Allegheniense*, while in the latter it is ovate and produced. It therefore resembles also in its proportions the genus *Herpctocephalus*, Huxl., from the Irish Coal Measures.

The parietal bones extend to opposite the posterior margins of the orbits, are then gradually contracted, and form an acuminate prolongation on each side the wedge-shaped frontals. The prefrontals are thickened on each side the front, behind the external nares. The sutures defining the frontals anteriorly, the nasals and the premaxillaries behind can not be made out. The median longitudinal suture is a marked and zigzag one, and can be seen as far posteriorly as the anterior margin of the orbits. The external nostrils are large, and opposite the inner margin of the orbit on each side. This separation of the nares is associated with a greater transverse extent of premaxillaries than in some of the species. These have been set with numerous teeth, judging by their small impressions; no larger ones have left traces, and no traces of any on the maxillaries.

A fragment of mandible remains, but without teeth or external surface. It shows a large internal (dental) canal.

Total length of cranium, 25.5 lines; with do. 3 lines behind orbits, 24.0; do. do. between orbits, 7.5; do. do. between nares, 5.0; do. do. between occipital condyles, 2.2; do of supraoccipital bone, 6.0; do. of right parietal, 6.0; extent of premaxillaries, 8.7; length of orbit, 6.0.

This species differs from the *Tuditonus radiatus* in the larger and more posteriorly placed orbits.

TUDITANUS HUXLEYI, Cope.

Transactions American Philosophical Society, April, 1874.

Represented by a considerable portion of the face and muzzle of a single individual. A portion of the left mandible, supporting three teeth, remains in place, and almost the entire boundary of the right orbit is preserved.

The fragment indicates a much larger species than any other referred to the genus, and, next to the *Leptophractus obsoletus*, the largest of the Batrachians of the Ohio Coal Measures. Without more complete remains, it is not easy to determine its generic relations finally.

The form of the head is probably elongate, and the muzzle neither very obtuse nor elongate. The orbit is rather small, and near the mid-

dle of the length of the specimen, which is, however, incomplete at both ends. The sculpture of the surface of the head posterior to the orbits, as well as round their borders and for some distance in front of them, consists of a rather coarse pitting. On the middle line, between the orbits and on the muzzle, the intervals become narrower, and are confluent into transverse ridges or a delicate reticulation. The surface of the mandible displays a coarse reticulation.

The teeth are stoutly conic, and with delicately striate grooved cementum. They are slightly recurved.

This species differs from the *T. radiatus* and *T. obtusus* in the absence of the aræ into which the sculpture is thrown.

Longitudinal diameter of orbit, 0.019 m.; length of alveolar border supporting three teeth, .013; diameter of basis of tooth, .003; eight pits in, .010.

Dedicated to Prof. T. H. Huxley, *facile princeps* among English systematists, and an important contributor to the knowledge of the extinct Batrachia.

TUDITANUS LONGIPES, Cope.

Sauropleuræ longipes, Cope; Transactions Amer. Philos. Soc., 1874. (Separata, p. 10.)

The structure of the cranium in this species is quite unknown, the part preserved being too much injured to furnish characters. The only genus with which it can be compared in the structure of the skeleton remaining is *Tuditanus*, and it is possible that some of the characters of the latter, in which the present species is deficient, may yet be observed in it. The type, however, *T. brevirostris*, has thoracic shields and very weak limbs, so that they are well distinguished. As to crania, the only one of *Tuditanus* which could, by reason of size, belong to *T. longipes*, is *T. mordax*, the *T. radiatus* and *T. obtusus* being too large.

The vertebræ are not elongate, and the ribs are quite well developed. The neural spines of the dorsal vertebræ are vertical laminae, subquadrate in outline. The tail is elongate, being proportioned much as in lizards of typical forms. Of scapular arch I can find nothing, but the iliac bones are preserved. They are short, flat rods, slightly narrowing towards the base, which is a transverse expansion, with the distal margin presenting two faces separated by an angle. The limbs are well developed, the ulna and radius separate.

The general form is slender, and the limbs, especially the anterior, are elongate; the general form is more Lacertilian than Batrachian. The

abdominal armature of slender rods, in chevrons with anterior angle, shows that it belongs to the usual type of the Coal Measures.

Body long, slender, with long neck and long tail. Ribs nineteen or twenty-one, moderately curved, the anterior stouter and with widened extremities, the posterior more slender and drawn out to a fine point. Dorsal vertebræ one and a half times as long as wide, with well-developed neural spines. These are rather narrower than high, the height about equaling the length of the centrum. They are rugose, with small tubercles, which are sometimes confluent into ridges.

The humerus is longer than the ulna and radius, which are of equal lengths—that is, about as long as four dorsal vertebræ. The ulna and radius are not widely separated, and expand at the carpal region. The humerus is rather more slender, and is distally expanded. The digits are not all preserved. One metacarpal is seen at an interval beyond the fore-arm, and a series of phalanges extends beyond the metacarpal. The latter is about half as long as the fore-arm, and a little longer than the first phalanx, which is, like the former, very slender. Parts of two or three phalanges of perhaps other digits appear alongside, as though turned backwards. The femur is about as long as the humerus, equaling six and three-quarter posterior dorsal vertebræ. Proximally it is enlarged gradually, and terminates regularly, so far as can be seen, as it is partially concealed beneath the distal extremity of the ilium.

Length of vertebral column between pelvis and humerus, 0.070 m.; length in front of humerus, .0235; length of caudal series preserved, .070; length of humerus, about .0185; length of ulna and radius, .012; length of part of fore limb in line, .0455; length of ilium, .007; length of femur, .020; number of chevron rods in .004, seven.

A single specimen of this Batrachian was obtained by Prof. Newberry at Linton. It is in a good state of preservation.

LEPTOPHRACTUS, Cope.

Proceedings Acad. Nat. Sci., Philad., 1873, p. 340.

Established on various portions of the cranium of a large Batrachian allied to the Labyrinthodontia. The only parts which can with certainty be referred to it are the jaws of three specimens which include only the anterior parts. These bear large teeth, round in section at the base, but with compressed acute apex, with a cutting edge on the anterior face, the enamel delicately grooved, as external indication of the laby-

rinthic structure. A characteristic feature is seen in the presence of a large elongate tooth in the upper jaw, in the position of a canine, which much exceeds in length any of the others. The sculpture of the cranium is little marked in the known species. In the type the lower jaw is marked with inosculating grooves. Two species are known, which are the largest of the Linton fauna.

LEPTOPHRACTUS OBSOLETUS, Cope.

Proceedings Acad. Nat. Science, Philadelphia, 1873, p. 341.

The teeth are rather distantly grooved for some distance above the base. They are of different sizes; the smaller are compressed, and with fore and aft cutting edges.

The external surface of the dentary bone is marked with short oblique grooves along its middle region; above these are grooves which inosculate, forming a figure like an open net dragged in the long direction. Excepting the grooves, the teeth are smooth. The smaller ones are close together, and their crowns are curved backwards; the larger ones are at more remote intervals; both have enlarged bases. Whether both forms are in the same series I can not determine. There are from four to five of the smaller in an inch.

Depth of fragment of jaw (margin wanting), .075 m.; length of smaller teeth, .019; length of longer do., .023; width of vertex at middle scuta, .176; width of paired median scuta, .056; width of single do., .036; length of single do., .048.

Some vertebræ were found at the same locality, but there is no evidence as to the species to which they may have pertained. They are short, concave on one end, and probably so on the other. The centrum of one is .012 m. in diameter; neural arches injured. (Pl. 39, fig. 3.)

A third and larger specimen was found by Prof. Newberry during the field season of 1874. It includes an oblique view of one side, and the top of the cranium from the posterior part of the orbits to the end of the muzzle, with the corresponding part of the alveolar region of the dentary bone, with teeth. The bones of the skull appear to have been rather light, and though the surface is irregular, the sculpture consists only of shallow impressions of varying size and intervals. The orbits are also badly defined, but appear to have been large, and separated by a narrow frontal bone. The premaxillary bone is preserved, and shows clearly the sutures that separate it from its fellow and from the maxillary. A large foramen—perhaps the nostril—separates it from the maxillary, so

that it forms an irregular crescent. It supports two teeth, of which the anterior is the larger, but there were, perhaps, others in advance, as the alveolar border is imperfect towards the end of the muzzle. The anterior two teeth of the maxillary bone are followed by a strong groove which rises towards the side of the muzzle. At first sight this gives the impression of the maxillo-premaxillary suture, and makes it appear that both premaxillary bones are preserved, and that the foramen above described separates the premaxillary spines, instead of representing the external nostril. The cutting edges of the teeth of these bones have, however, one direction, whence they represent one side of the cranium only; were both sides represented, the directions of the tooth axes would be reversed.

The premaxillary and maxillary teeth exhibit a cutting edge on the outer posterior margin of the distal half; the base of the crown is sub-round in section. The line-like grooves are distinct but not numerous, their intervals measuring .75 mm. Beyond them the enamel is smooth. The second maxillary tooth is larger than the first, which is equal to the last premaxillary. The third and fourth maxillaries are equal to the second, but the fifth is larger and longer, exceeding all the others. The teeth of the dentary bone differ from those of the upper jaw in having the cutting edge of the crown on the anterior aspect, while the posterior border is obtuse. There is an obtuse cutting edge on the posterior margin of the anterior mandibular teeth.

This description is derived from an adult animal, as the maxillary-teeth in some instances are partially worn away by friction on their anterior and outer faces.

Length of maxillary bone preserved, .146 m.; length of do. supporting five teeth, .073; length of first maxillary tooth, .015; diameter of do. at base, .006; do. of second at base, .008; do. of fifth at base, .010; length of basis of fifteen teeth of dentary, .145; length of ninth tooth, .020; diameter at base of do., .008.

The *Leptophractus* was about as large as an adult alligator, and exceeded in size any of the other species here described.

EURYTHORAX, Cope.

Established on a large thoracic shield of peculiar form. It is a median, and exhibits on its outer or lateral borders broad, smooth surfaces for the contact of the overlapping margins of the lateral plates. The form is subround, with a large excavation from the posterior margin on each

side. The narrowed portion left in the middle behind has a convex outline. Sculpture none. The form resembles remotely the corresponding scute of *Tuditonus punctulatus*, the posterior narrow face representing the xiphisternal process of that species.

EURYTHORAX SUBLÆVIS, Cope.

Proceedings of American Philosophical Society, 1871, 177.

The specific characters expressed by this shield are best perceived in the measurements.

Length, .0715 m ; greatest width (imperfect), .078; width of lateral concavity, .039; Some delicate radiating grooves are seen on the exposed surface, but they are very shallow. They are not visible on the faces of contact.

This represents one of the largest species of this fauna, having pertained to an animal of probably four feet in length, perhaps longer. It will be desirable in future to compare it with the corresponding part of the *Tuditonus Huxleyi*, though the latter, so far as known, is the smaller species.

SAUROPLEURA, Cope.

Proceed. Acad. Philad., 1868, p. 215; Transac. Amer. Philos. Soc., 1869, p. 15.

Vertebræ and ribs well developed; limbs four, rather large, five digits in the fore foot; carpus cartilaginous. Ventral armature of closely arranged rhomboidal scuta, arranged in lines, which are closely placed in chevrons, with the angle anterior.

In neither of the species of this genus have the usual three thoracic shields been observed. The abdominal scuta, on the other hand, are much like those of *Colosteus*, but are very much thinner.* So far as known, there is considerable resemblance between these genera, but the osseous vertebral column and ribs of *Sauropleuræ* are unknown in *Colosteus*. The long ribs and strong limbs of this genus are proportioned much as in true lizards.

The cranium referred to the *S. Newberryi* partakes of the characters of the abdominal scutella in its light construction. The teeth are of the Labyrinthodont type, with deeply inflected enamel and acute apex.

* When I state (Transac. Acad. Philos. Soc., 1869, p. 16) that *Sauropleuræ* lacks the ventral armature, *thoracic* armature is intended.

SAUROPLEURA DIGITATA, Cope.

Proceed. Acad. Nat. Sci., Philad., 1868, p. 216; Transac. Amer. Philos. Soc., XIV., p. 15.

This species is represented by but one individual, which has been spread over a surface of the coal slate, exhibiting ventral armature, dorsal region with ribs, and anterior and posterior limbs. Of skull and caudal vertebræ nothing remains.

The dermal bands are arranged as in *Oestoccephalus*, i. e., in parallel lines directed obliquely forwards and continuous on the median line, forming there a chevron. The component scuta are oat-shaped, and acuminate at both ends. They are moderately imbricate in an antero-posterior section. On the pectoral region between the fore limbs the series of scutella assume different directions, forming chevrons directed *backwards*, and forming with those of the belly a complex X.

The humerus, ulna, and radius are rather stout, and of a size relative to the body, as in common types of existing sauria; the ulna and radius separate. There is no carpus, but five well-developed digits have phalanges in the following numbers, commencing on the inside: 3, 4, 5, 6, 5. The last phalanx of the second is obscured, and it is not positive that the number is as given; it is more probable than that it should have been 3. The outer toe has been more slender than the others; the distal phalanges of all the toes are short conic, as in Salamanders. Thus this form differs from *Amphibamus*, where the numbers are 3, 3, 4, 5, 4, showing a lower development of limbs.

The ribs are long and curved as in reptiles, and judging by their distances the vertebræ are short; the latter are not well defined, but there is no indication of prominent spines of any kind.

The pelvic bones and portions of those of the hind limbs are present, but so obscured and confused as not to be made out. Enough remains to show that the hind limbs are considerably longer than the anterior.

This species had a length of body about equal to that of a fully grown *Chamaeleo vulgaris* of the largest size, or of a half-grown *Menopoma*. Thirteen ribs on one and several on the other side are preserved; where they terminate, probably at the pelvic region, some small or rudimental ribs project from the two or three first caudals. Three ribs and their interspaces extend over five lines. The humerus is broken, but its length can be clearly made out to be seven lines; it has no condyle, and is dilated at both extremities. The ulna and radius are distinct, truncate, hollow, and dilated at the ends. Length of ulna, 5.1 lines; distal width, 1.8 lines. The fourth toe is considerably longer than the others;

the fifth is next, and reaches the basal third of the antepenult phalanx of the fourth; the third is very little shorter; the first is not quite so long as the first two of the third. The bones of the hind limb are not readily distinguished. They are evidently much longer and larger than the anterior. No part of a foot is preserved.

SAUROPLEURA NEWBERRYI, Cope.

The type specimen of this species exhibits a portion of the back of the skull, and a considerable part of the course of the body, with abdominal scuta and fore limbs. No vertebræ can be definitely discovered, nor are ribs visible. The cranial fragment is the upper surface of the epiotic and adjacent elements, and a broad band of the posterior parts of these is seen to be smooth, and is preceded by a slightly roughened surface. The abdominal scuta are rhombic or diamond-shaped, and are thin and light, not massive, as in the *C. scutellatus*, and are sometimes marked with a median longitudinal keel; one extremity is quite prolonged. The fore limb is large, especially the humerus, which is much dilated distally, and has a strong crest on the outer side from near the proximal end. The ulna and radius are much shorter, and more dilated proximally than distally; they are well separated. No phalanges are preserved.

Length of humerus, .035 m.; proximal width of do., .008; distal width of do., .014; length of ulna, .019; proximal width of do., .008.

A second specimen displays similar abdominal scutella. The posterior part of the skull is exhibited in profile. The mandible is deep behind and sculptured with longitudinal grooves, which, when interrupted, become pits. The teeth are straight, acute, and grooved at the base. It is, of course, not absolutely certain that this specimen represents the species *C. Newberryi*, but it is evidently nearly allied to it.

A third specimen consists of a cranium whose bones remain on opposite halves of a block, so that their external surface is not visible. It must, however, be smooth or but little sculptured, otherwise some impress would be visible through the bones. These are thin and light, and display their outlines more clearly than usual. The four protruberant angles mark the posterior border of the skull, the external or quadrate being the most prominent, and separated by a deep notch from the median pair, which are separated by a concavity only. The quadrate is covered by an oval bone, probably squamosal; the bones which project into the median angles are externally epiotic and internally exoccipital. The quadrato-jugal arch is well marked, forming, with the maxillaries, the straight boundaries of a wedge-shaped head. The muzzle is lost, but

the maxillaries do not exhibit any curvature, and the snout was doubtless acuminate. The orbits are long and narrowed in front. The teeth are like those described in the last specimen, rather long, straight, acute, and striate at the base. A section shows the enamel to be deeply inflected. The only inequality in their length is the slightly diminished size posteriorly.

This is one of the larger species of the Linton beds. In none of the specimens are the thoracic scuta preserved.

Width behind, .067 m.; width between epiotics, .033; width at anterior angle of orbits, .040; width of interorbital region, .013; length from epiotic to orbit, .025; length of orbit, .027; width of orbit, .013; length of a maxillary tooth, .004; diameter of do. at base, .002.

COLOSTEUS, Cope.

Trans. Amer. Philos. Soc., 1869, p. 22.

This genus was proposed for *Ganocephala*, allied to *Archegosaurus*, but differing as follows:

There are no traces of vertebral centra or spines, or of ribs, in portions of six individuals preserved. No sclerotic bones can be found in one cranium partially preserved. There appear to be two pairs of very short limbs. The usual three sculptured pectoral bones are present, consisting of a rhombic medial, and a pair of half rhomboid laterals. The abdominal region is protected by a series of scales which extend obliquely forwards to the medial line, where they meet, forming chevrons. They are closely approximated, and are composed of rhomboidal scales which have a convex external and internal face, in transverse section, and which overlap at the extremities, and are in contact by faces which are oblique in both the longitudinal and transverse directions.

The exact form of the muzzle can not be made out. It is, however, not elongate, nor yet of the broad rounded form of *Pelion*. Several teeth are preserved. There are two kinds, which occupy the margins of the maxillary and dentary bones. The anterior teeth appear to be longer than the posterior, though the latter are mostly broken off. Most of the teeth are coarsely incised sulcate for perhaps their basal half. Two long teeth behind the distal extremity of the dentary are, on the other hand, very finely and sharply striate for their basal half; the tip is sub-cylindric, and very prolonged and acute. A small, dagger-shaped tooth near the base of one of the posterior may belong to the successional, or to a small outer series. A series of four elevated tooth bases, with a broken crown,

of much smaller size than those of the jaws, belongs to the vomerine or a palatine series. The row is single and uniform.

The superior face of the cranium is injured, but the component bones appear to have possessed a radiating sculpture of no great distinctness.

The form of the body seems to have been long and fish-like, with little contraction near the limbs. Caudal extremity is not preserved. There are three metacarpals of the anterior limb preserved. A narrow longitudinal bone extends posteriorly from the lateral pectoral bone. Its extremity is broken, but a flat, narrow, longitudinal bone, with a dilated extremity curved outwards, may belong to it, or be the humerus. I find no distinct traces of branchial arches.

The affinities are thus obviously to *Sauropeltura*, and it is not beyond possibility that future investigations may prove it is the same, though this is not probable at present.

Portions of seven individuals of one species, and of one each of two others, have been obtained by Dr. Newberry at the Linton locality. They may be distinguished as follows:

Surface of the thoracic bones pitted, with numerous radiating grooves prolonged from elongate pits	<i>C. foveatus.</i>
Surface of bone with numerous deep grooves separated by sharp, elevated ridges, about twenty on a lateral shield.....	<i>C. scutellatus.</i>
Surface of bones with few shallow grooves, median with interrupted wrinkles, lateral with 10 to 12 low ridges	<i>C. pauciradiatus.</i>

COLOSTEUS FOVEATUS, Cope.

Loc. cit., p. 24.

A very elegant sculptured median pectoral plate represents this Batrachian. It is larger than most of those of *C. radiatus*, but smaller than the one last described. The posterior and median parts of the plate are pitted to the number of six in five mm. The pits are separated by sharply defined ridges. They elongate towards the anterior parts of the plate, resembling elongate hexagons, and the ridges approach radii, though not more elevated than the cross septa. The beveled margins are rugose also, except at the edges.

Length of the bone, .045 m.; greatest width, .025; width of posterior margin, .021.

From Linton, Columbiana county, Ohio. Prof. J. S. Newberry, Coll. No. 20.

COLOSTEUS SCUTELLATUS, Newb.

Cope; Proceed. Amer. Philos. Soc., 1871, p. 41.

Pygopterus scutellatus, Newberry; Proc. Acad. Nat. Sci., Philada., 1856, p. 98.

Colosteus crassiscutatus, Cope; Transac. Amer. Philos. Soc., XIV., 23.

One of the specimens of this species consists of a supero-lateral view of a crushed cranium and anterior part of the body. The median pectoral bone appears as a sagittiform plate, with thin edges, rounded lateral angles, and a thin median prolongation behind. The greater part of the borders of the right orbit are distinct, and display the continuity of the malar and supratemporal regions. The ramus mandibuli is longer than the cranium proper. The number of the teeth can not be determined, but they are rather large, and traces of their existence do not extend behind the orbits. The length of the long anterior mandibular tooth is .005 m., and the diameter at the base .001 m. Diameter of base of a superior maxillary, .002 m. The approximate length of the mandibular ramus is .0715 m.; longitudinal diameter of the orbit, .0072 m.; length of median pectoral plate, .036 m.; width of same, .019 m.

The sculpture of the pectoral shield is strong, and extends to the edges; the middle of the median plate is almost smooth. The lateral plates are nearly right-angled triangles, with the anterior angle much prolonged.

Other specimens (Nos. 4 and 10, collection of J. S. Newberry) show that the abdominal scutellation commences immediately behind the pectoral bones. Those near the median line are similar to the external, and their junction forms a zigzag line. The depth of these scales is oblique, and is somewhat greater than the width. Thus one angle projects, and gives the surface an angularly ribbed rather than continuous character. The following measurements express their dimensions relative to other parts of the body:

Width of median pectoral, 0.0138 m.; width of three pectorals restored, .054; width of scale band of belly, .064; length of ulna and radius, .0108; length of metacarpus, .006. Scales in .01 m., transverse measurement, 5.2; scales in .01 m., longitudinally on rows, 1.75. Radii of lateral pectoral crossing, .01 m., seven.

The measurements express the small size and weakness of the fore-limb. Another specimen (No. 18), in which the impressions of the scales are of the same size as in the preceding specimen, the impressions of what may be femur, and ulna, and radius, are visible, which are

of considerably smaller size than the limb just mentioned. They are but doubtfully these elements.

Length of proximal element, .004 m.; length of two distal elements, .0038.

COLOSTEUS PAUCIRADIATUS, Cope.

Transactions American Philosophical Society, April, 1874.

Established on median and lateral pectoral plates of perhaps two individuals, the latter of which I formerly referred to the *C. scutellatus*. It belonged to a larger specimen than either of the preceding, and is distinguished by the paucity and weakness of its ridges. These are entirely transverse on the posterior third of the length, but are interrupted and irregular on the median portion; the anterior third is almost smooth.

The lateral shield is little larger than the largest of *C. scutellatus*, but resembles the median plate in its low and distant carinæ. An arc drawn at about the middle of a radial line from the outer angle crosses about eleven of these ridges; in *C. scutellatus* twenty exist in the same space.

The median plate is pyriform, with the posterior angle little prolonged, and the anterior not narrowed and rather short. The lateral shield is a right-angled triangle, the inner or thin edge concave posteriorly; the posterior convex.

Length of median, 0.063 m.; width of median, .040; width of lateral behind, .0242; length of lateral, .045.

APPENDIX.

Specimens of the following genera and species accompanied the material described in the preceding pages, but are not included in the latter on account of their position being, in the writer's opinion, among the fishes. The interesting form *Peplorhina* is as yet but partially known.

PEPLORHINA, Cope.

Proceedings Acad. Nat. Sci., Philad., 1873, p. 343.

One of the specimens of *Peplorhina* displays the lower side of the cranium, and on it two large jugular bones, one on each side, on the inner side of the mandible. They are elongate, the posterior border oblique, so as to present an apex on the inner side; the inner edge is thin, the outer thickened; the surface smooth, with a very obscure longitudinal striation. Between their anterior extremities is a subround disciform bone in the position of the basi- or glossohyal. The mandibular rami extend round its anterior margin, and posteriorly nearly to the end of the jugular. The symphysis is a curious interdigitation of three fingers into as many notches, and the dentaries near them are marked with symmetrical pores, which look like the exits of mucous ducts. Three are on the superior and two on the inferior margin of the bone, and a sixth is immediately between the upper and lower inner ones. These pores correspond with the mucous ducts of the lateral line observed in the scales of the type. The teeth are numerous placed in a patch on the vomer, or at least the roof of the mouth, and are short, conic, acute, and smooth. They are discoverable as far backwards as the anterior end of the jugular plates. The large opercular bones are smooth, and the head is covered above with nearly smooth, thin scuta. The head is wide behind, and though contracted forwards, the muzzle is broadly obtuse. Irregular masses, perhaps remains of cartilage, follow the skull, in which a few ribs are scattered.

The other specimen displays the smooth operculum, patch of vomerine teeth, and several separated scuta of the surface of the cranium. These have rounded angles, one or more convex sides, and very obscure radiating ridges. The body is covered with imbricated scales with cycloid free margins, whose surface is marked with a tubercular sculpture.

The characters relied on as indicative of the reference of *Peplorhina* to the fishes are (1) the presence of opercula like those of *Conchiopsis*; (2) the presence of jugular bones; (3) of oval imbricated scales; and (4) the absence of ambulatory limbs. The thin scutiform cranial bones, the dense patch of vomerine teeth, and the mucous ducts of the bones and scales are all ichthyic characters. As no limbs have been discovered in three specimens preserved in the appropriate regions, their nature, if existing, can not be determined at present.

PEPLORHINA ANTHRACINA, Cope.

L. c., p. 343. *Conchiopsis exanthematicus*, Cope; *Loc. cit.*, p. 342.

Represented by a cranium entirely preserved as to its outline, with adjacent portion of space for chorda dorsalis and osseous ribs. The head is covered with thin scuta, which are very faintly sculptured with a few raised lines. The gular shields are oval and sculptured with elevated points, producing a weakly rugose surface. The teeth above described are on this fish. There are six in 3 mm.

Width at shields, .055 m.; width at middle muzzle, .030; length of head, .045.

Scales large, well imbricated, covered with minute tubercles, which form a rugose sculpture; each one is .01 m. in elevation, and three enter .02 longitudinally. The gular scuta and opercula are smooth, except a band of shallow grooves round the margin.

Length of gular scutum, .021 m.; length of scute behind it, .014.

CTENODUS, Agass.

But one specimen representing this genus has been found at Linton, a remarkable circumstance when taken in connection with its abundance in other coal fields where fossil Batrachians occur.

CTENODUS OHIENSIS, Cope.

Proceedings Acad. Nat. Sci., Philad., 1874, p. 91.

The type consists of a mould of the scuta of the upper surface of the cranium. The top of the head is covered with angular plates or scuta arranged in the following manner on the region preserved: Two symmetrical scuta occupy the median line, one in front of the other. One of these is a longish or coffin-shaped hexagonal, with the suture with

the other concave. The latter is more ovoid, broad, and convex next the first mentioned, and somewhat more contracted at the opposite extremity. Beyond this are two shields joining by a straight suture on the middle line. Besides this one, they have two concave sutures for scuta at the farther end, two concave lateral sutures, and a straight one to the adjoining median scutum, whose suture is also concave. On each side of this median plate is a large area, surrounded before, outwards, and behind by smaller scuta—three in front, two at the side, and two behind. Commencing with the first, No. 1 has been already described; No. 2 is small, oval, and antero-posterior; No. 3 is an antero-posterior pentagon, with the narrowest-side inwards; No. 4 is a similar transverse pentagon; No. 5 is an antero-posterior pentagon, which presents its shorter lateral facet inwards; No. 6 has a similar character, but is smaller, and with more definite angles. Another series of scuta is seen outside of these at one end of the series. Three of this set bound the front and side of each of the median pair above mentioned, leaving a short facet next its fellow unaccounted for.

The sculpture consists of radiating ridges and tubercles, which are most broken near the centers of the scuta.

The pits and grooves of the cranium are obtuse and shallow, and the latter do not inosculate. An angular elevation commences at the middle of each central area, and extends across the middle line at the point of junction of the paired and single median scuta.

The specimen above described accompanied the jaws of the *Leptophractus obsoletus*, and were so marked as to induce the belief that they were found together. It was, therefore, originally described in connection with that species, but was afterwards assigned to its present position.

DESCRIPTIONS OF FOSSIL PLANTS
FROM
THE COAL MEASURES OF OHIO.
BY
E. B. ANDREWS.

DESCRIPTIONS OF FOSSIL PLANTS.

The Coal Measures of Ohio are rich in fossil plants in all parts of the stratigraphical series, but the space allotted to this department of palæontology in this volume admits of the publication of descriptions of only a part of the new forms which have been discovered.

I have, therefore, limited myself to an interesting group of plants found together in a thin band of bituminous shale located a little above the base of the Coal Measures, near the western margin of the coal field, in Perry county, about two miles east of Rushville. This layer of shale is from twenty-five to thirty feet above the top of the Maxville limestone, the Ohio equivalent of the Chester limestone, a Lower Carboniferous formation in Illinois. The shale containing the plants I have never found except at one spot, where it is exposed in a ditch by the roadside, and all the plants were found within the limits of a few yards square. More extended explorations would doubtless bring to light other new forms.

There was here a little marsh in which grew many fine ferns and other plants, nearly all of which are new to science. Some of these are allied to types hitherto regarded as Devonian, and some others belong to a type found chiefly in the Mesozoic. This fact gives no little interest and significance to the locality.

While these plants are found near the base of the Coal Measures in Ohio, their stratigraphical position is more than two thousand feet above the base of the series, as revealed in the geosynclinal basin of West Virginia, which was first filled with strata of the Coal Measures before any similar formations took place upon the ancient marginal Waverly plateau of Ohio.

GENUS MEGALOPTERIS, Dawson.

This is a genus established by Principal Dawson to include a form of Devonian fern discovered by Prof. Hartt, and named by him *Neuropteris Dawsoni*.

I have found several additional species near Rushville. They are all, except one, quite closely allied to the form found by Prof. Hartt. The exceptional one has something of the appearance of an *Alethopteris*, and

is a much smaller plant than the others, but, from a careful study of many specimens, I am led to think it properly belongs to the genus *Megalopteris*. Some fragments of another form of the same genus have been found, but they are too imperfect for description.

The Ohio species are of rare interest, not only for the beauty of the plants, but because they are found, not in the Devonian, but in the Coal Measures. Between them and any Ohio Devonian rocks are the Maxville limestone (equivalent of the Chester, Illinois, group) and the Lower Carboniferous Waverly sandstone group.

MEGALOPTERIS HARTTII (sp. nov.).

Plate 46, figs. 1 and 1a.

Frond very large, linear-lanceolate, somewhat enlarging towards the top, simply pinnate. Rachis flat, striate, winged below the lower pinnae, the alate portion extending lower in some specimens than in others, and the external margins of the wings not always quite regular in outline. Pinnae alternate, diverging at an acute angle, unequal-sided, the lower side decurring and broad, and the upper narrowed toward the base or medial nerve; linear-lanceolate, obtuse, broadly decurrent, each extending down the rachis to the inferior pinna; margin distantly and irregularly crenate, but often entire; medial nerve flat, dissolving below the apex. Veins very numerous and fine, diverging at a very acute angle, forking twice or thrice, sometimes four times, and passing in a curve to the border. This fine fern was about two feet in height. Fig. 1 shows a terminal portion of the plant of natural size, but the medial nerves are too prolonged; 1a shows the venation magnified.

Found near base of Coal Measures, in Perry county, near Rushville.

MEGALOPTERIS MINIMA (sp. nov.).

Plate 48, figs. 1, 1a, 2, and 3.

This species resembles *M. Harttii*, but is a very much smaller plant. Rachis striated. Frond simply pinnate. Pinnae lanceolate and sometimes acuminate, comparatively short and narrow, strongly decurrent, connected above the base; margin entire; midrib flat, as in *M. Harttii*, but extending nearer to the apex. The nerves fork two or three times, as in *M. Harttii*, but are more open and diverging, coarser, and less numerous. In *M. Harttii* the nervules diverge from the medial nerve at a very acute

angle, each having a regular curve from its point of origin to the margin, while in this species they diverge at an angle much less acute, and are generally somewhat bent at the fork, or at a short distance above it, thus breaking the continuity of the curve. This feature is not quite perfectly shown in fig. 1*a*, which represents the nervation enlarged. Fig. 2 represents the largest specimen yet found. Fig. 3 shows the apex of a very small one.

Location same as previous species.

MEGALOPTERIS OVATA (sp. nov.).

Plate 47, figs. 1, 2, and 2*a*.

The pinnæ of this species are ovate or ovate-lanceolate, the terminal ones obovate. The nervation is similar to that of *M. minima*. This plant resembles considerably *M. Harttii*, but its pinnæ are very much shorter and more ovate, and the nervation is coarser, like that of *M. minima*. In the decurrent portions of the pinnæ the nerves are so curved as to reach the margin nearly at right angles, while in *M. Harttii* they reach the margin at an angle of 45°, or less. It is a smaller and shorter plant than *M. Harttii*. Fig. 1 represents a terminal portion of the plant. Fig. 2 shows a lower portion, with the short, broad leaves which characterize this species. Fig. 2*a* shows the nervation near the base of the decurrent portion of the leaf.

Locality same as that of previous species.

MEGALOPTERIS LATA (sp. nov.).

Plate 47, figs. 3 and 3*a*.

This species is established on very large detached pinnæ. Margin entire. Nervation as in *M. Harttii*, but differing in this, that after the last forking the nervules are parallel and proceed straight to the margin, and not in a continuous curve. The pinnæ are sometimes bifurcated, as shown in fig. 3. No apex of pinna has been found, and the form of termination is unknown. The size of the pinnæ (of which some of the fragments are over twenty centimeters long and five centimeters wide) and their nervation indicate a distinct species. The plant resembles *M. Dawsoni*, Hartt, but the pinnæ are not rugose, and the nervules do not fork near the margin, and are not continuously curved, but proceed straight and parallel to the margin, the straight or tangential portion occupying from half to two-thirds the distance from margin to midrib.

In all the preceding four species of *Megalopteris* the first forking of the nervules of the pinnæ is often obscure, not showing distinctly except where the parenchyma has been partially removed.

Locality same as previous species.

ARCHÆOPTERIS STRICTA (sp. nov.).

Plate 49, figs. 2 and 2a.

Fronde bi-pinnate. Rachis comparatively thick, straight, regularly and thinly striate. Pinnæ alternate, somewhat closely set, growing out of rachis at an angle with it of 70° to 75°, rarely as small as 45°. Pinnules alternate, oblanceolate, obtuse, decurring on the narrow rachis, disconnected to the base, with a strong nerve dividing near the base into three to five branches, which themselves fork once or twice before reaching the margin.

This beautiful fern is allied to *Cyclopteris Jacksoni*, Dawson, from the Devonian, but is in all respects a smaller and more delicate plant. It differs from it not only in its much shorter pinnæ, and in the less acute angle made by them with the rachis, but in having its pinnules disconnected to the base, not imbricated. The nervation is also quite different. In *C. Jacksoni* the veins are slightly curved and nearly parallel, while in this species they are once or twice dichotomous from near the base, with branches diverging and fan-like.

It is still more like *C. Roemeriana*, Goepp., but is a more delicate species, with shorter, open, straight pinnæ proceeding from rachis at a greater angle, with pinnules shorter and less distant, with one strong branching nerve instead of several, and a regularly thinly striated rachis.

Dr. Dawson suggests *Archæopteris* as the generic name of this group, in preference to *Palæopteris*, Sch., which is preoccupied. Fig. 2 shows the nervation and leaf magnified.

Locality same as the last.

ORTHOGONIOPTERIS (genus nov.), Andrews.

Fronde simply pinnate. Pinnæ alternate, lanceolate, or oblong-linear, rounded and tapering to an acute point, entire or undulate, enlarged and decurrent on lower side, rounded on the upper to the middle nerve, and joining it a little above the point of its attachment to the rachis. Medial nerve prominent, thick, ascending to the apex. Nervules very fine

and numerous, uniform, at right angles to the middle nerve, decurring to it at the point of attachment, forking once very near the base. The rectangular character of the nervation has suggested the name of the genus.

This genus is allied to *Tæniopteris*, Brongt., *Angiopteridium*, Sch., and *Neriopteris*, Newb. The nervation is similar to *Tæniopteris*, but *Tæniopteris* has a simple frond, while this is pinnate. In *Angiopteridium* the frond is pinnate, and the pinnae have cordate or rounded bases and acute-angled nervation, with a marginal and bivalvular fructification; and in *Neriopteris* the pinnae are similarly cordate or rounded, with acute-angled nervation, and with a supposed marginal fructification. In this genus the pinnae, on the other hand, are decurrent below, rounded and free above, with rectangular nervation. It has more of the characters of the *Danxia* than any of the *Pecopteridæ* of the Coal Measures, the veins being parallel, equal, and slightly turning up at or near the margin. It differs, however, by the decurrent base of the leaflets, in which feature it is allied to the *Alethopteris*. It doubtless belongs to the order of the *Tæniopteridæ*. None of this order have hitherto been found so low as in the Coal Measures. *T. multinervis*, Weiss, belongs to the Upper Coal Measures and Permian of Europe. The only plants of this order found in this country, so far as I know, are *Tæniopteris* (*Macrotæniopteris*, Sch.) *magnifolia*, Rogers, in the Triassic coal field near Richmond, Virginia, and *T. vittata*, reported by Dr. Hitchcock, from the Triassic of the Connecticut valley. In Ohio plants of this type are singularly found associated with several Devonian types, such as *Megalopteris*, Daw., and *Archæopteris* (*Palæopteris*), Daw.

ORTHOGONIOPTERIS CLARA (sp. nov.).

Plate 50, figs. 1 and 1a.

Frond pinnate. Stalk of medium size, with numerous closely set pinnae. Pinnae alternate, oblong-linear, rounded, and tapering to an acute point. Entire or slightly undulate, diverging from the rachis at a not very acute angle; margins contiguous or over-lapping; the upper margin rounded at the base, meeting the medial nerve a short distance from its junction with the rachis; the lower margin decurrent, the alate portion extending down the rachis nearly to the medial nerve of the next pinna. Medial nerve very prominent, extending to apex of pinna. Nervules very fine and close, leaving the medial nerve at a very acute angle, forking once very near their bases, then, bending sharply down to a horizontal line, extend parallel nearly to the mar-

gin, where they slightly curve upwards, the leaf being to a slight degree revolute. Thirty-five nervules are counted on the border in the space of one centimeter. The frond is 37 centimeters in length, with about 15 pinnae on each side. The pinnae are from 9 to 11 centimeters long, and nearly 2 centimeters wide. The lower portions of many of the pinnae are obscured in the specimen, but several show the basal structure, but too obscurely to be well represented in the figure.

In fig. 1 the nervules are not sufficiently fine and close. Fig. 1a shows the nervation magnified.

Location same as the last.

ORTHOGONIOPTERIS GILBERTI (sp. nov.).

Plate 50, fig. 2.

This species differs from the preceding by a relatively stronger rachis; pinnae of thicker substance, shorter, lanceolate, more distant, more evidently and broadly decurrent below, the upper basilar border curving to and reaching the medial nerve at a greater distance above its base. The medial nerve is prominent and well marked, but not so thick as in the last species. The veins or nervules are finer and closer, and show less tendency to curve upwards at the border, which is somewhat thickened.

Forty-five nervules are counted in one centimeter of the margin. Having but a single fragment of this species, belonging, probably, to the middle of the plant, or, perhaps, a little below it, it is impossible to judge of its length, but it was evidently a large and beautiful fern. The pinnae are about 6 centimeters long and 15 millimeters broad.

Locality same as the last.

ALETHOPTERIS HOLDENI (sp. nov.).

Plate 51, figs. 1, 2, and 2a.

Frond simply pinnate, large, with a very thick striate rachis one centimeter wide near its base, which is covered with a thick mass of scales. Pinnae long and narrow (4 to 7 centimeters long, and 7 millimeters broad), decurrent, greatly diminished in length toward the base; sub-opposite toward the top, sub-alternate toward the base; oblique in the upper part, open and nearly at right angles toward the base; scythe-shaped, lanceolate, taper-pointed, with a prominent midrib extending to apex. Veins open, curving to the border, forking twice, once near the base, and again about one-third of the distance from midrib to margin, thence nearly parallel, reaching the margin at an angle somewhat acute.

This large and splendid fern is somewhat related to *A. Serlii* and some other species of the same section. The essential characters which separate it are, 1st, the great length of the frond, which measures at least fifty centimeters; 2d, its linear-lanceolate, or, rather, oblanceolate form, the leaflets decreasing in length toward the base; 3d, the linear, taper-pointed form of the leaflets; and, 4th, the always simple division of the frond.

Fig. 1 represents the lower part, and fig. 2 the top of the frond. Fig. 2a shows the nervation, but the nervules are generally more nearly parallel as they approach the margin than is here represented.

But a single specimen of this fine fern has been found.

Locality the same as the last.

ALETHOPTERIS BUNBURYI (sp. nov.).

Plate 51, figs. 3 and 3a.

Pinnate or bi-pinnate, with a slender rachis. Pinnæ alternate, almost contiguous, ovate-lanceolate or broadly oval. The margins of the upper leaves sometimes entire, while those of the lower are more undulate or slightly lobed. The upper leaves are attached to the rachis by the whole base, while the lower ones are somewhat narrowed and very slightly cordate.

Medial nerve strong, extending nearly to the apex. Nervules generally once, sometimes twice dichotomous, rising from the medial nerve at an acute angle and curving to almost a right angle with it, and proceeding to the margin in lines nearly parallel.

This pretty fern resembles very much *A. tæniopteroides*, Bun., found in the coal fields of Cape Breton. The nervation is quite similar, but the leaves are not decurrent, are more pointed, and are generally lobed in the margin.

Locality same as the last.

ALETHOPTERIS MAXIMA (sp. nov.).

Plate 50, figs. 3, 3a, and 3b.

This species includes a few fragments of a plant remarkable for the size of its pinnæ, which resemble in nervation the *A. tæniopteroides* of Bunbury.

No basal part of a pinna has been found, and nothing is known of the method of its attachment to the rachis.

The pinnæ are oblong-linear, entire, rounded, and tapering to an acute

point. The medial nerve is strong, and extends to the apex. The veins are once or twice dichotomous, forking generally near the midrib, curving and extending parallel to the border at a slightly acute angle, bending upward a little upon nearly reaching it.

The fragment shown in fig. 3 indicates a very large, straight leaf, which measures 7 centimeters in length and $1\frac{3}{4}$ centimeters in width. Another leaf, found in the same location, is slightly curved. Fig. 3a shows the apex of a leaf, and fig. 3b the usual venation. The fragments all show a series of dots, which at first suggest fructification, but as they are situated between the veins, they are probably merely dots of an iron oxide. While the venation is similar to *A. tæniopteroides*, Bun., the leaf is much larger and more pointed. If a true *Alethopteris*, its leaf is larger than that of any described species of that genus, except *A. ingens*, Daw., from which it differs somewhat in venation.

Locality same as the last.

HYMENOPHYLLITES BALLANTINI (sp. nov.).

Plate 49, fig. 1.

Fronde tripinnatifid. Primary rachis thick, striated, flexuous. Pinnæ distant, alternate, decurring, with a thickened rachis. Pinnules numerous, alternate, once or twice lobed, decurrent; ultimate divisions linear, narrow, short, acute, either free to the base or united above the middle; two to three millimeters long and one-half millimeter broad, or less. Veins thin, dichotomous, each division extending to the apex of the lobe. At the base of the decurrent secondary rachis some pinnules are attached to the main rachis, even descending along it.

I know of no species to which this one may be compared. Its first and general appearance is that of a *Sphenophyllum*.

Locality same as the last.

EREMOPTERIS MARGINATA (sp. nov.).

Plate 52, fig. 1 and fig. 2.

Fronde bi-pinnately divided. Pinnæ alternate, divided into numerous diverging, oblique, acuminate, confluent lobes. Veins numerous, dividing like the pinnæ. Pinnules decurring along the rachis. Rachis of medium size, bordered by a series of half round compressed appendages resembling small scales, and forming a narrow crenulate border or wing.

This appendage, which is not observed in any other species, passes up the rachis to the point where the decurrent lobes join it. This peculiar margin gives the name to the species.

This plant has a general resemblance to *Sphenopteris artimesiaefolia*, Sternb., on which Schimper has founded the genus *Eremopteris*, but differs from it principally in the lobes of the pinnæ, which in *E. artimesiaefolia* are more elongate and wedge-shaped, while in this plant, with the same nervation, the lobes are very distinctly pointed.

Fig. 2 represents a more macerated form of the plant.

Locality the same as the last.

LEPIDOPHLOIOS LESQUEREUXII (sp. nov.).

Plate 53, fig. 3.

Stem or cone covered with rather small, rhomboidal, imbricated scales of nearly equal breadth and depth, measuring about seven millimeters in each direction. The upper part of each scale depressed, as in *Lepidophloios*, the depression bordered below by a curved transverse ridge, from the middle of which descends a similar longitudinal ridge, on each side of which is a small oval cicatrix. A single similar cicatrix is seen in the center of the upper depressed space. If this depressed space was ever tripunctate, this feature is not now discernible. One of the scales is uncovered in its lower portion, and shows an apparent fibrous or woody structure. It does not appear to be the striated axis of a cone. The specimen, however, as a whole, has a strong resemblance to a cone. It is unlike any species of *Lepidophloios* I have seen, and still less like any form of *Lepidostrobus*. The figure represents the natural size.

Locality same as the last.

LEPIDODENDRON RUSHVILLENSE (sp. nov.).

Plate 53, fig. 4.

Cicatrices rhombic (almost square), with the lateral diagonals slightly longer than the vertical, very close together. There are three oval depressions a little above the middle of scar; two of them in a horizontal line, and the other placed centrally a little above. Another circular depression appears near the upper corner of the cicatrix, and transverse wrinkles in the lower part. The figure of *L. tetragonum*, given by Sternberg, is very indistinct, and that given by Dr. Dawson, in *Fossil Plants of Lower Carboniferous and Millstone Grit, Canada*, does not correspond to

my specimen, except in general shape, and in the circular depression in the upper corner. In my specimen I have some doubt whether this dot represents a true vascular leaf-scar.

This species bears no resemblance to Prof. Schimper's *L. quadratum*.

Locality same as the last.

Roots ?

Plate 53, figs. 1 and 2.

I have given these figures simply to add to the material necessary to be accumulated for the proper determination of these and similar root-like forms.

They are probably nothing more than submerged portions of an *Asterophyllites*, the ordinary leaves of which took the form of profuse branching rootlets. The only forms of *Asterophyllites* thus far found in the shale at this locality are *A. erectifolius* (pl. 49, fig. 3) and *A. ? minutus* (pl. 51, figs. 4 and 4a).

The "rootlets" could hardly belong to the former species, and, if to the latter, there is involved in the sub-aqueous growth an almost incredible change of habit, in the increased size of the stem and remarkable multiplication of the leaves.

Lindley and Hutton (Vol. I., pl. 18, *Fossil Flora of Great Britain*) figure a so-called *A. longifolia*, in which the leaves are long, and slender, and flexuous, and apparently branching, and very unlike the usual form of the leaves of that species. They appear to have grown on a submerged stalk.

Locality same as the last.

ASTEROPHYLLITES ? MINUTUS (sp. nov.).

Plate 51, figs. 4 and 4a.

This is a very minute, jointed plant, with relatively thick, stiff, pointed, verticillate leaves, curved upwards. Length of leaves, from one to two millimeters. Generally four leaves grow from each node. Leaves a little longer than the joints of stem. There are indications of a strong medial nerve, but this may be only a peculiar thickening of the leaf. The plant has a general resemblance to *A. gracilis*, Lesq., from Arkansas, but it is a more delicate plant, shorter in the joints, and the leaves have a stronger upward curve. It also resembles somewhat *A. parvula*, Dawson, from the Devonian of New Brunswick.

The fragments of the tiny branchlets are very abundant in a thin band or layer, scarcely more than a half inch in thickness, made up of a curious soft brown mass of vegetable matter, which never hardened into coal or bituminous shale. It is often pulverulent, and burns slowly without flame, retaining its fire like punk. I am inclined to think that the layer was formed from the comminuted fragments of this plant. No stems of *Calamites*, or of other allied forms, are found in this locality, except the *A. erectifolius* (pl. 49, fig. 3), and the curious rootlets figured in pl. 53, figs. 1 and 2.

Locality same as last.

ASTEROPHYLLITES ERECTIFOLIUS (sp. nov.).

Plate 49, fig. 3.

Stem slender, striate, articulate; joints one and a half centimeters long, and less. Leaves verticillate, very numerous, small, slender, pointed, single-nerved, nearly one-third longer than the joints of stem, curving upward and enveloping the stem.

Locality the same as the last.

CARDIOCARPON NEWBERRYI (sp. nov.).

Plate 46, fig. 2.

Nucleus somewhat heart-shaped, pointed at the top, covered with a thin epidermal coating, which, when removed, shows underneath the smooth body of a nut or seed, with vertical striæ toward the apex.

The wings are large and wide, opening outward, with curved lines at the apex of nucleus, and showing a division at the base as a place of attachment of the nucleus to a stem. They are minutely striated, the striæ not curving upward, but taking a nearly horizontal direction from the nucleal margin.

The width of the whole, both nucleus and wings, is about four centimeters; that of the nucleus about one and three-fourths of a centimeter. The depth of the nucleus is nearly equal to its width.

It is unlike any of the many forms figured by Dr. Newberry, who has given special attention to this genus from the Lower Coal Measures of northern Ohio, and after whom I have appropriately named this fine species. It resembles in its wings *C. Bayleyi*, Dawson, from the Devonian of New Brunswick, but the nucleus is wider and more acuminate in the apex.

The figure represents the only specimen found. The epidermal covering of the nucleus is covered with irregularly placed dots, as shown in the figure.

Locality same as last.

I have, in the foregoing descriptions, given the more important of the new forms thus far found in the thin shale bed near Rushville. Besides these, however, there are many other plants which have not yet been carefully studied. Among them are two species of *Cordaites*, one with a very long, broad leaf, probably *C. Robbii*, Dawson, from the Devonian of New Brunswick, and the other much narrower, with finer nervation. There is species of *Lepidodendron*, similar to one found at Jackson, over the lowest coal-seam, which is probably not new. There are numerous fragments of a large form of *Lepidostrobus*, but no complete specimen of a cone has yet been found. Leaves of *Lepidodendron* are very abundant, some of which are of great length. There is a large form of *Lepidophyllum*. An axis of a very long and curious cone, too indistinct to be well figured, indicates a new form. There is every reason to believe that further explorations in this shale bed will reveal many additional plants.

In conclusion, I wish to express my thanks to my esteemed friend, Mr. L. Lesquereux, of Columbus, whose attainments and publications in Palæontological Botany have conferred such great honor upon this department of science, for the kind interest he has taken in my work, and for the privilege of consulting his extensive and invaluable private library.

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ERRATA.

- Page 8, line 1, for "TRUNCATUS" read "TRUNCATA."
- " 93, " 8, " "body" read "border."
- " 153, " 4, " "7" read "6."
- " 154, " 5 from bottom, for "7" read "6."
- " 155, " 14 " " " "fragments" read "segments."
- " 156, " 7, for "7" read "6."
- " 163, " 3 from bottom, for "center" read "centers."
- " 191, " 15, for "rhombica" read "rhombicus."
- " 191, " 11 from bottom, for "opposed" read "apposed."
- " 203, " 7 " " " "c" read "a."
- " 217, " 12, for "tabular" read "tubular."
- " 250, " 2, " "plain" read "plane."
- " 327, " 14, " "SEREATA" read "SERRATA."
- " 351, " 14, " "Uroconylus" read "Urocordylus."
- " 368, " 14, " "MACRUROUS" read "MACRURUS."
- " 370, " 12 from bottom, for "fitted" read "filled."
- " 370, " 8 " " after "other" read "genus."
- " 371, " 12, for "proximately" read "proximally."
- " 372, " 11 from bottom, for "lennicorne" read "tenuicorne."
- " 373, " 8 " " " "spaces" read "species."
- " 374, " 20, for "four" read "five."
- " 476, " 11, after "end" insert "of."

NOTE.—The proof of Prof. Cope's contribution, from page 351 to page 385, was not read by the author, and he is to be absolved from responsibility for the typographical errors contained in this portion of his report.

J. S. N.

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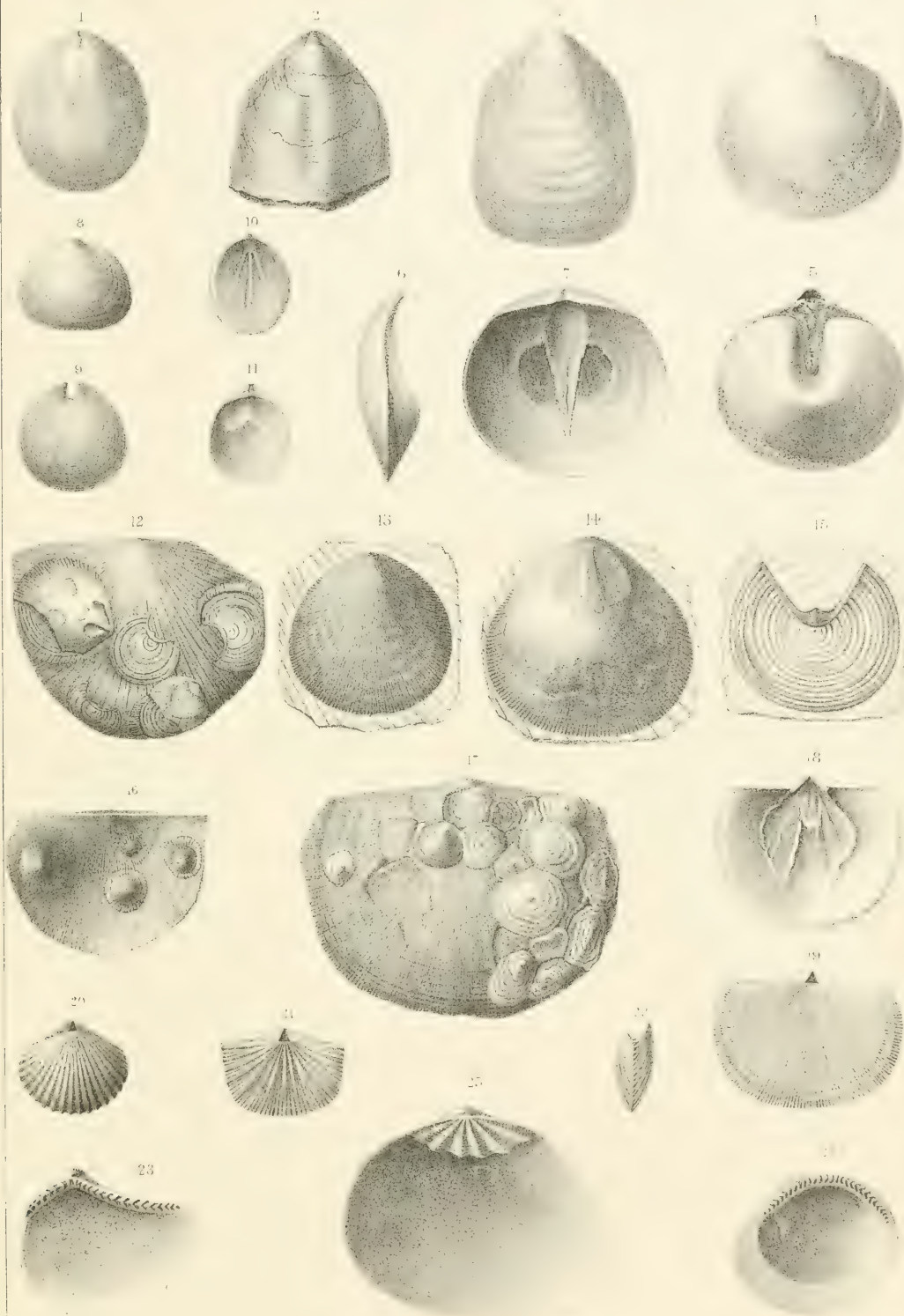


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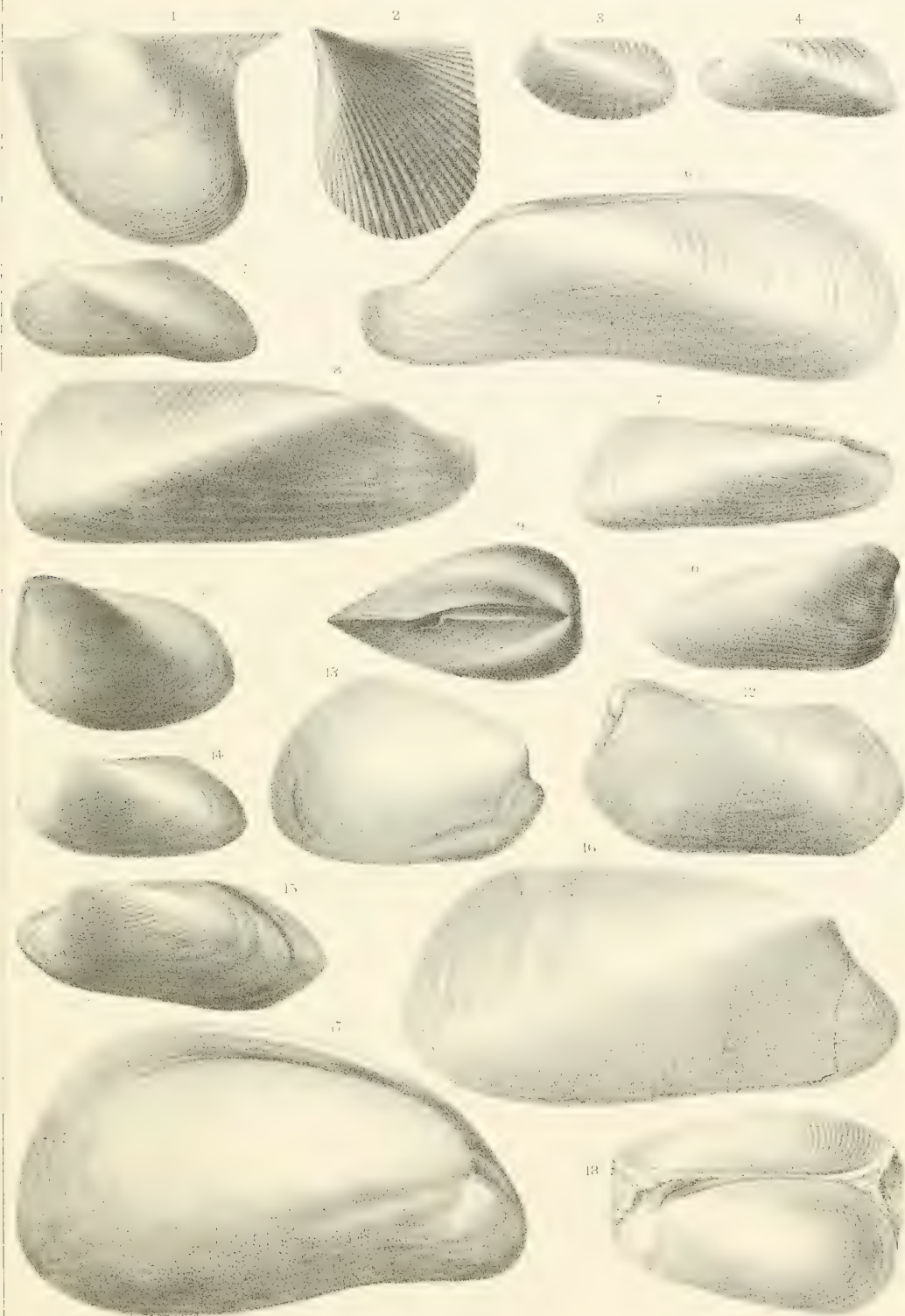


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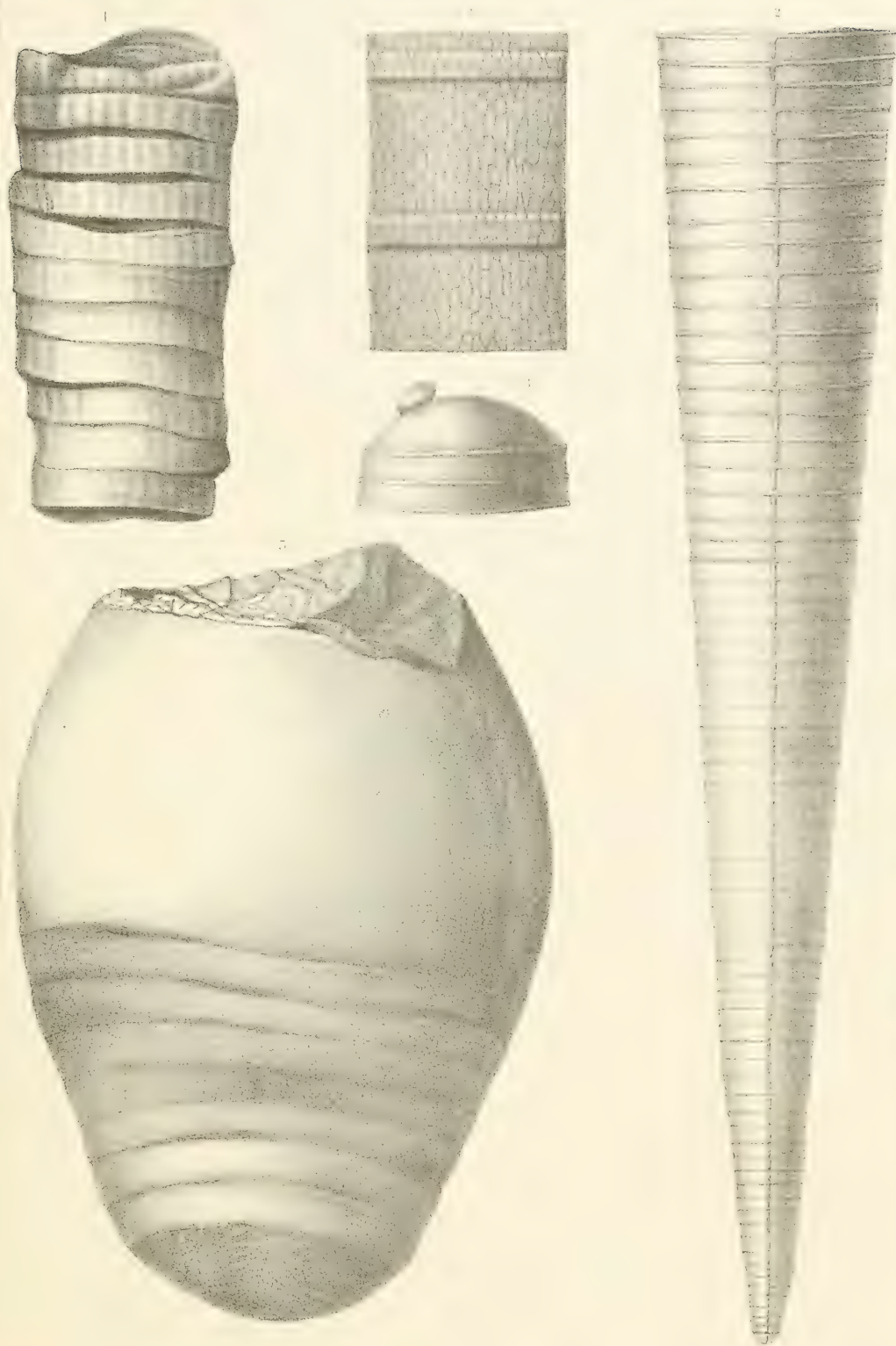


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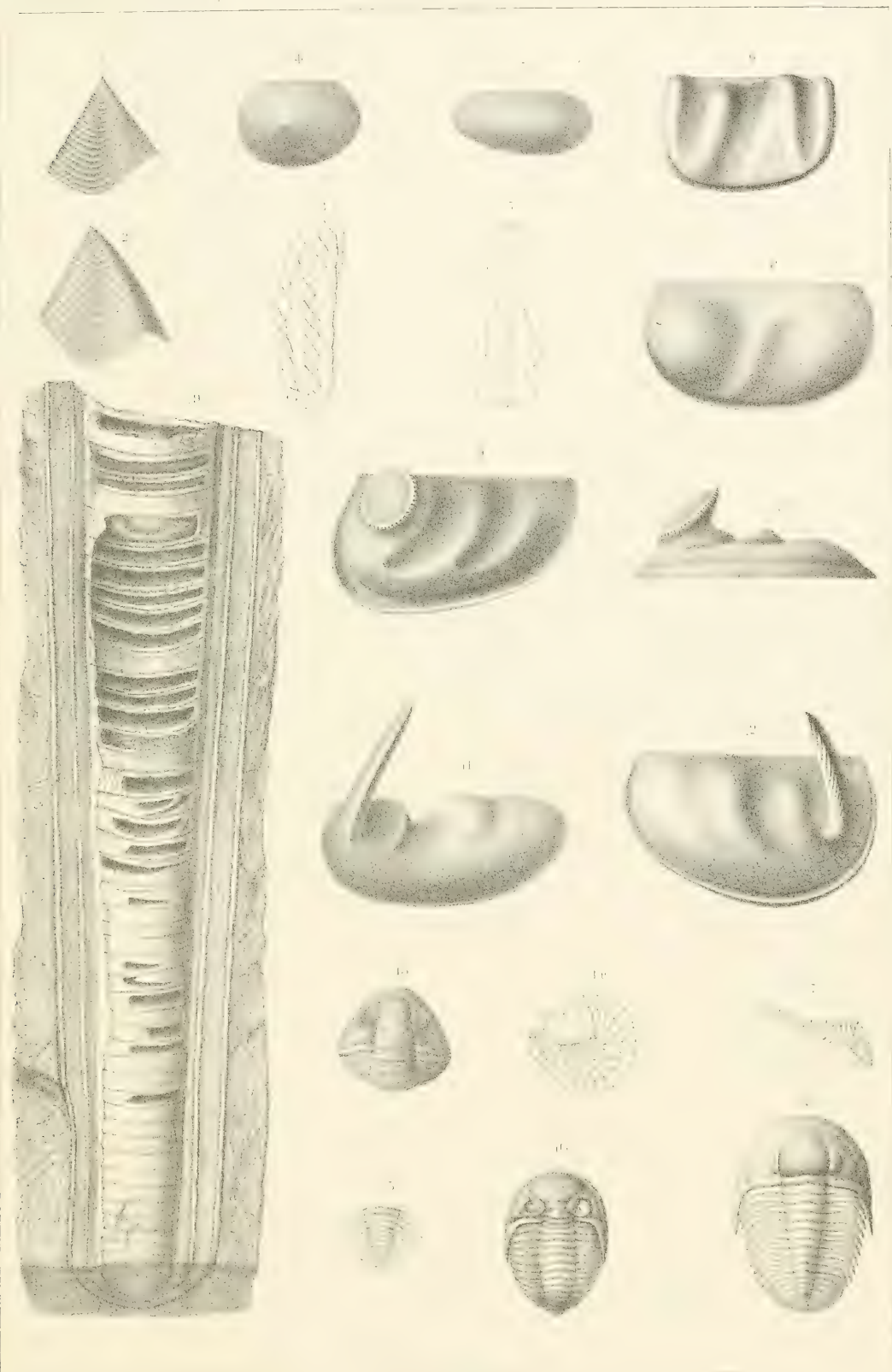


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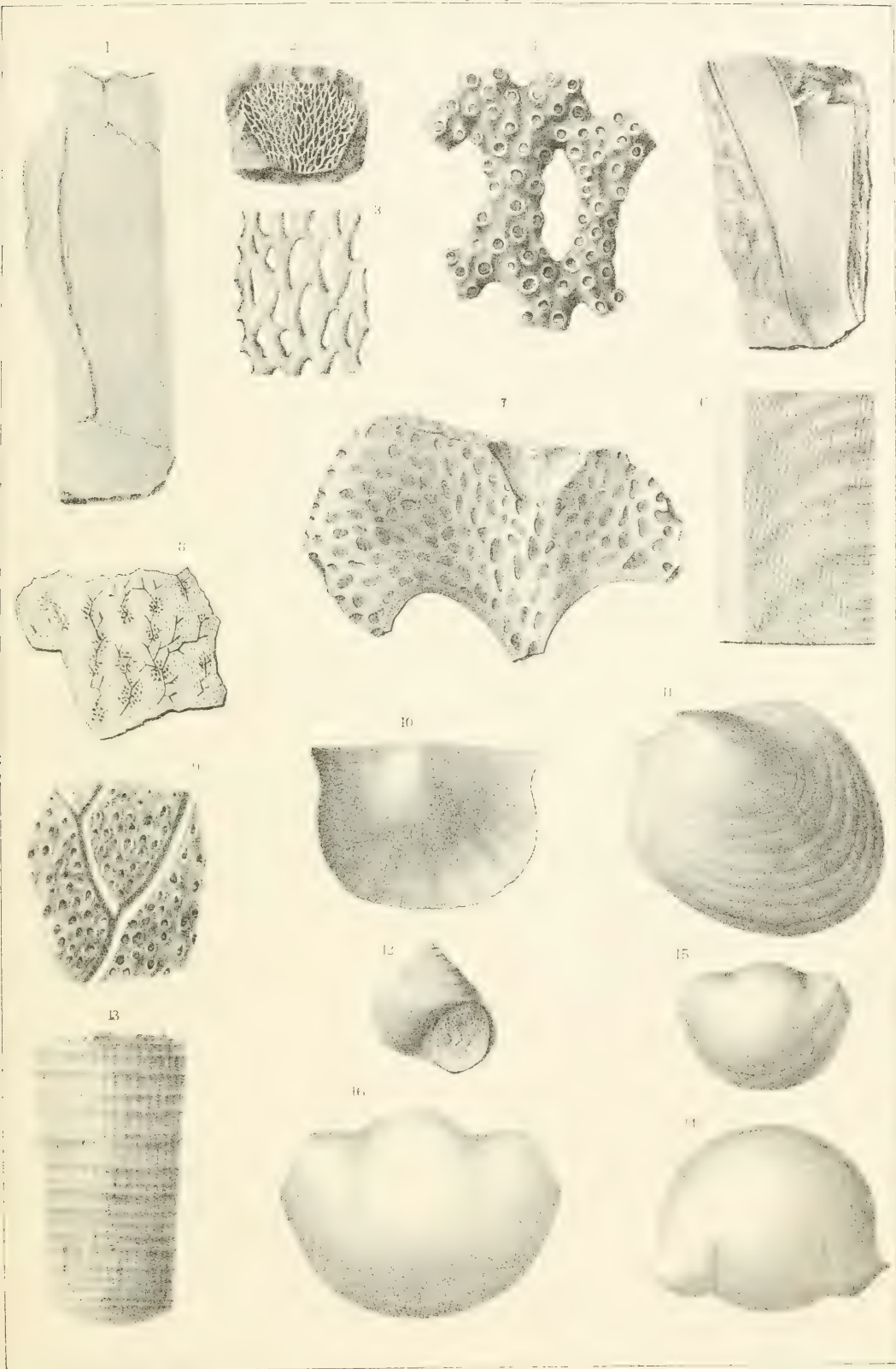


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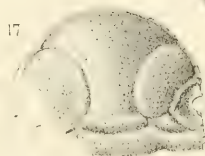
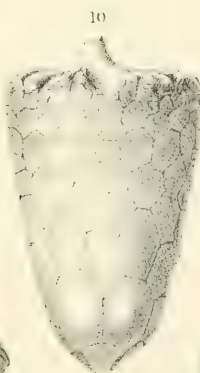
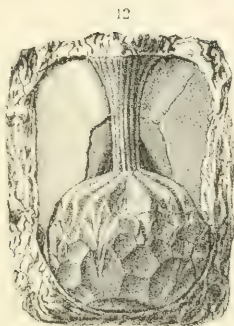
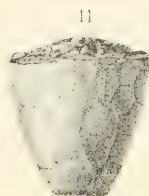
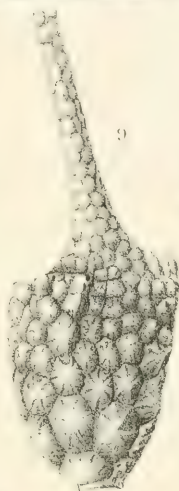
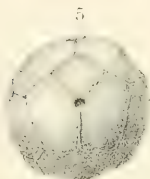
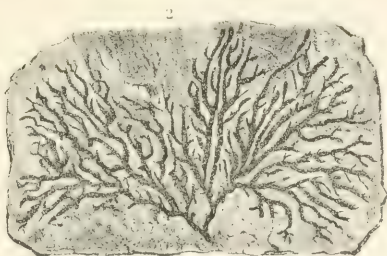
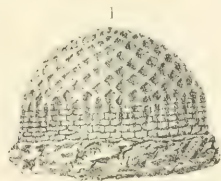


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Geological Survey of Ohio.

UPPER SILURIAN.

(Clinton & Niagara groups.)

PL. VII.

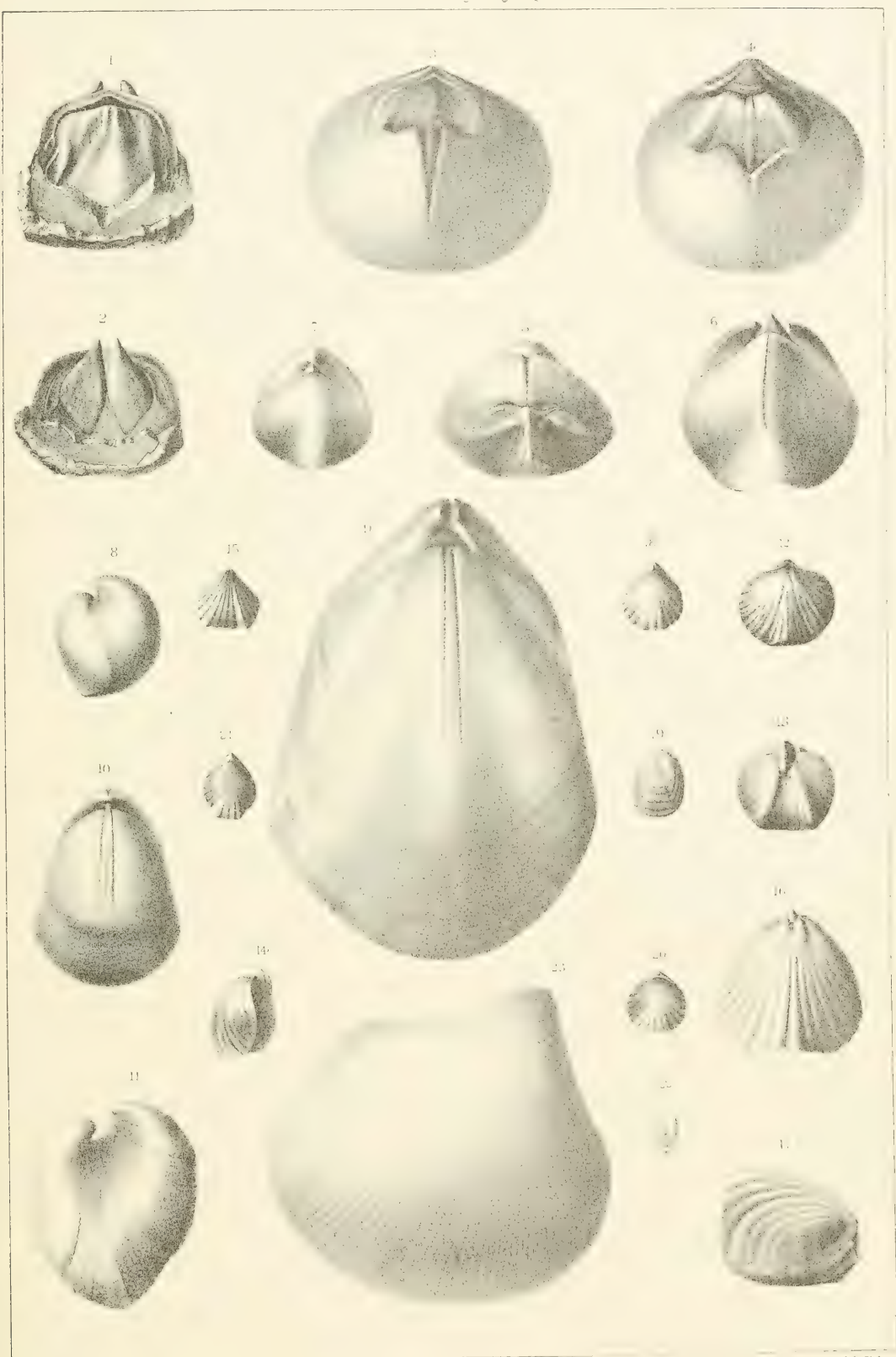


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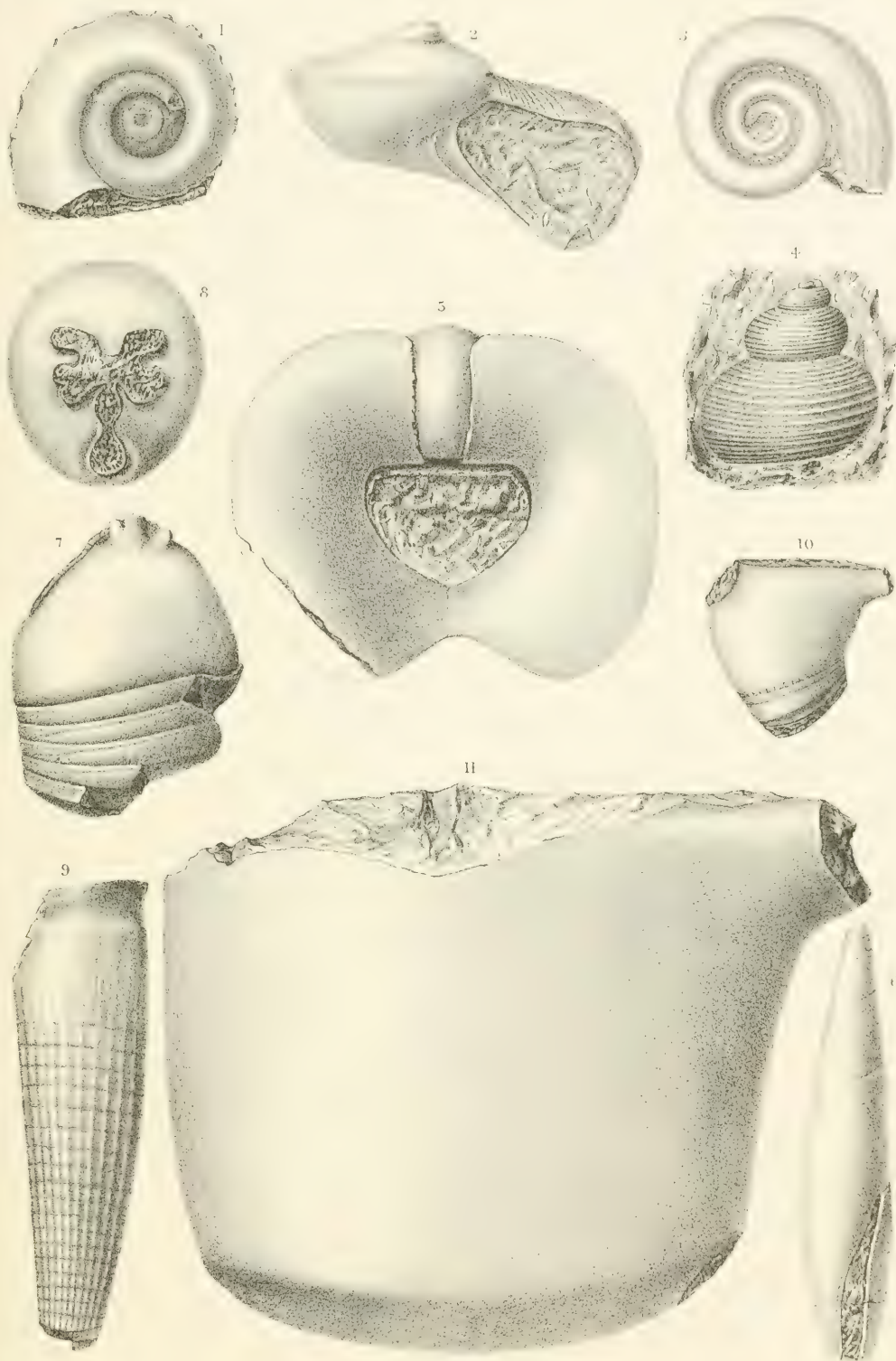


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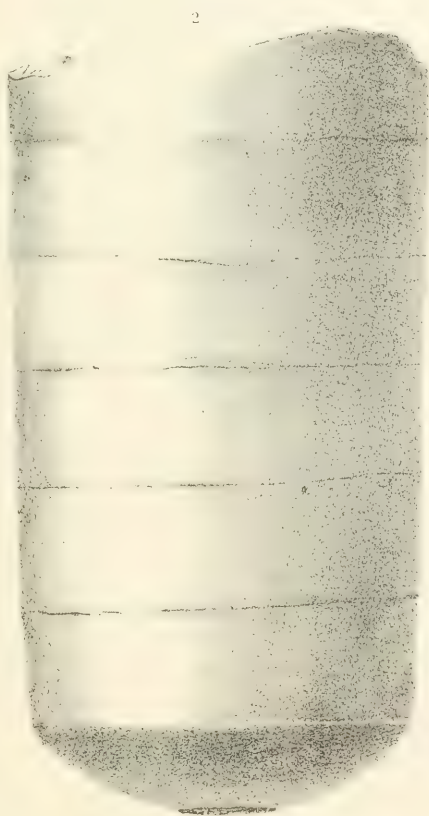
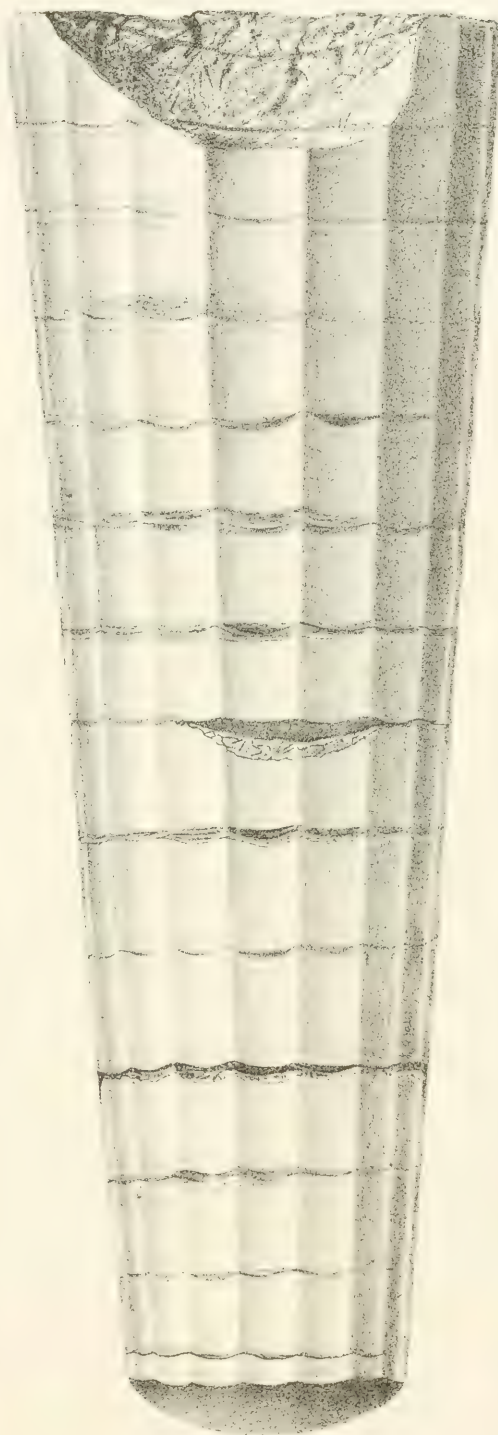


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Geological Survey of Ohio,

CARBONIFEROUS,

(Waverly group.)

PLATE 10.

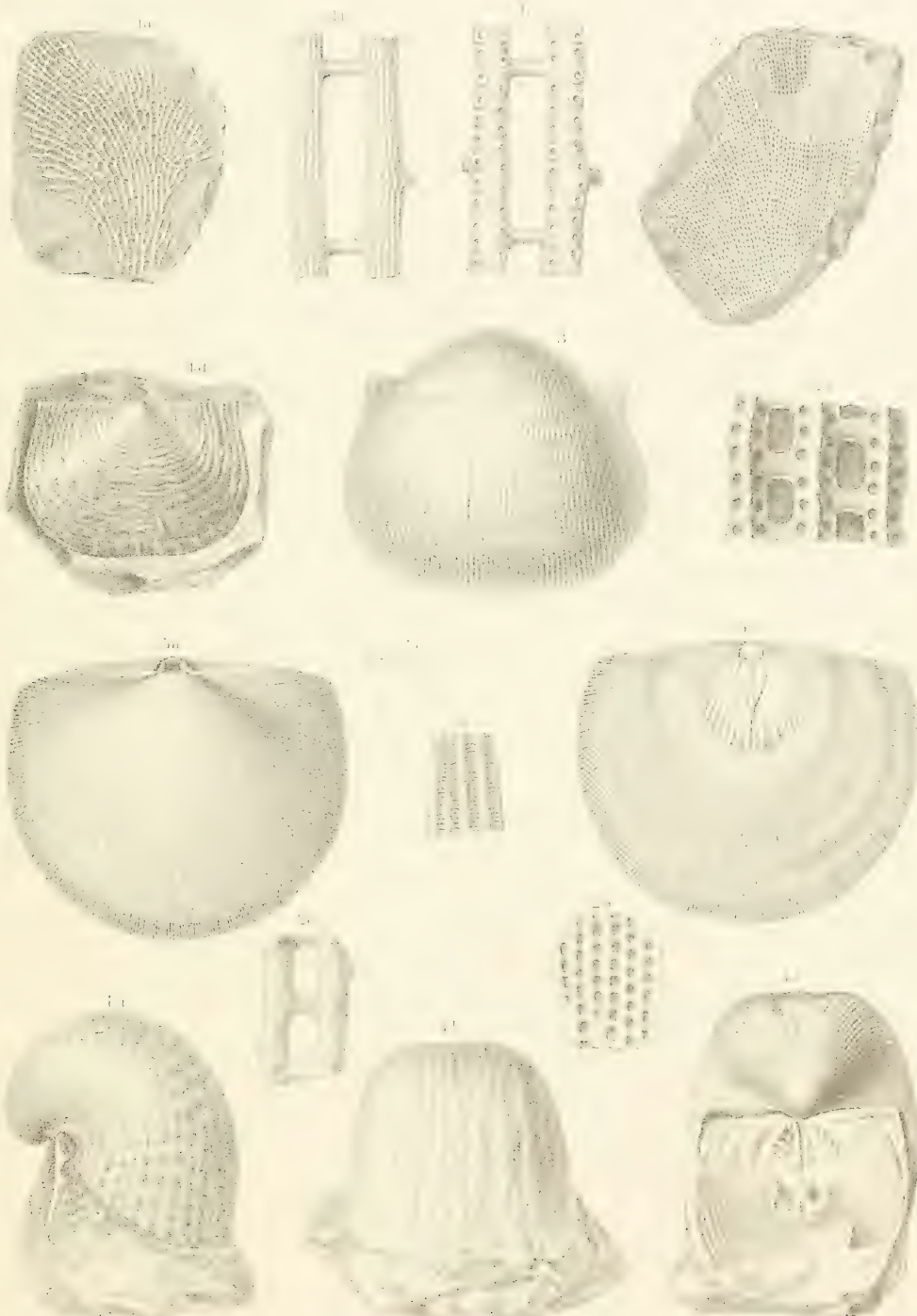


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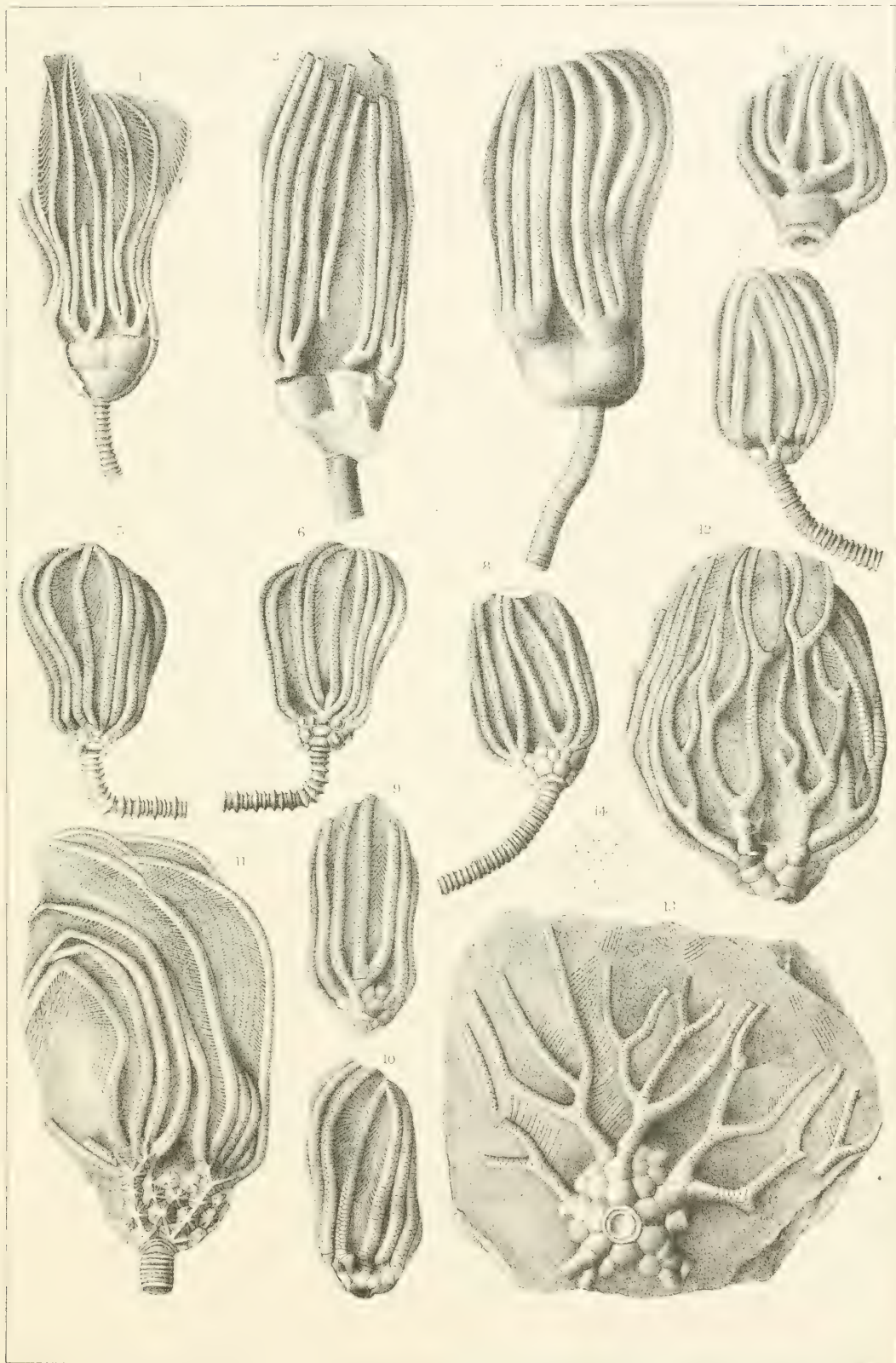


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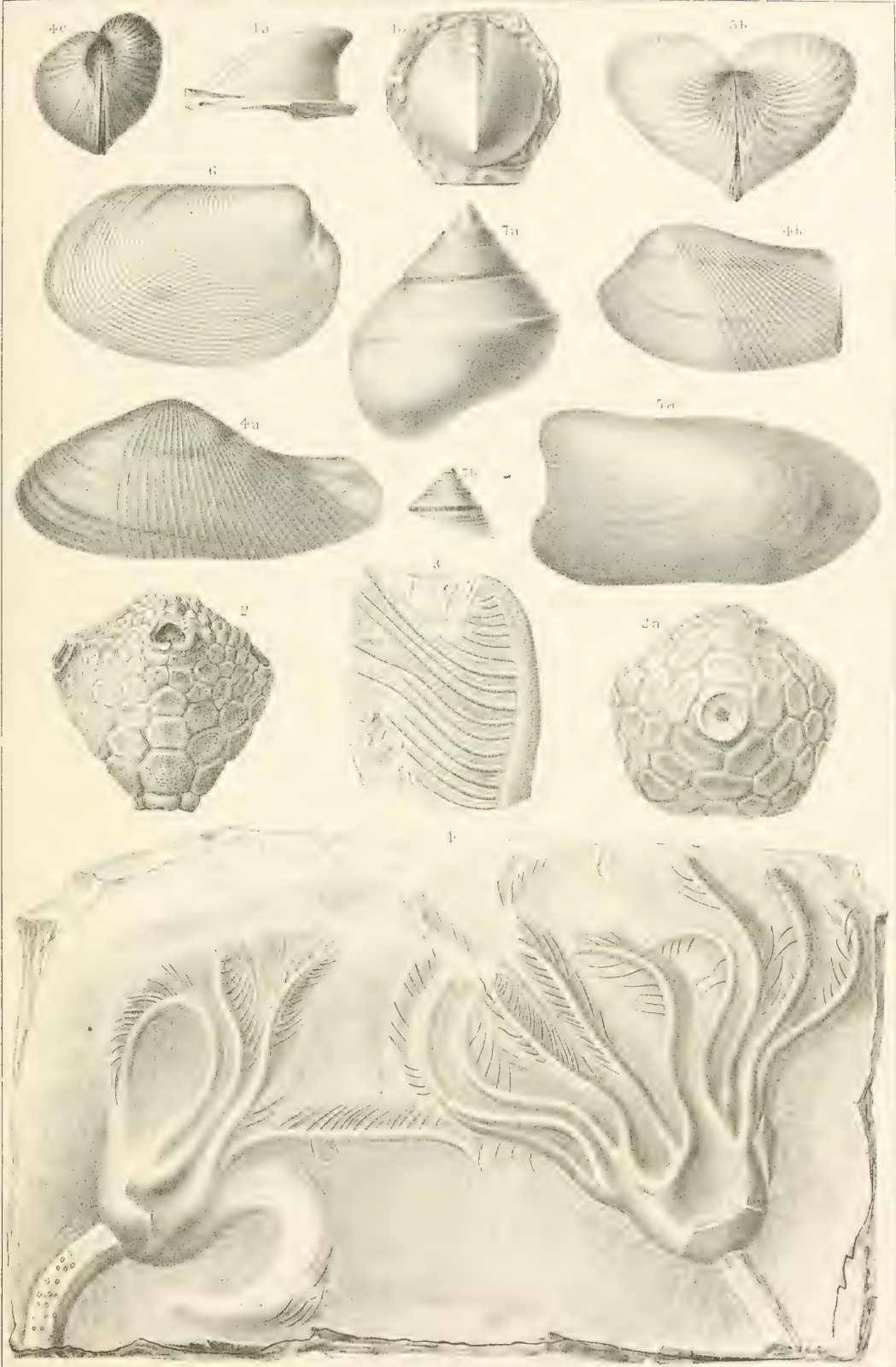


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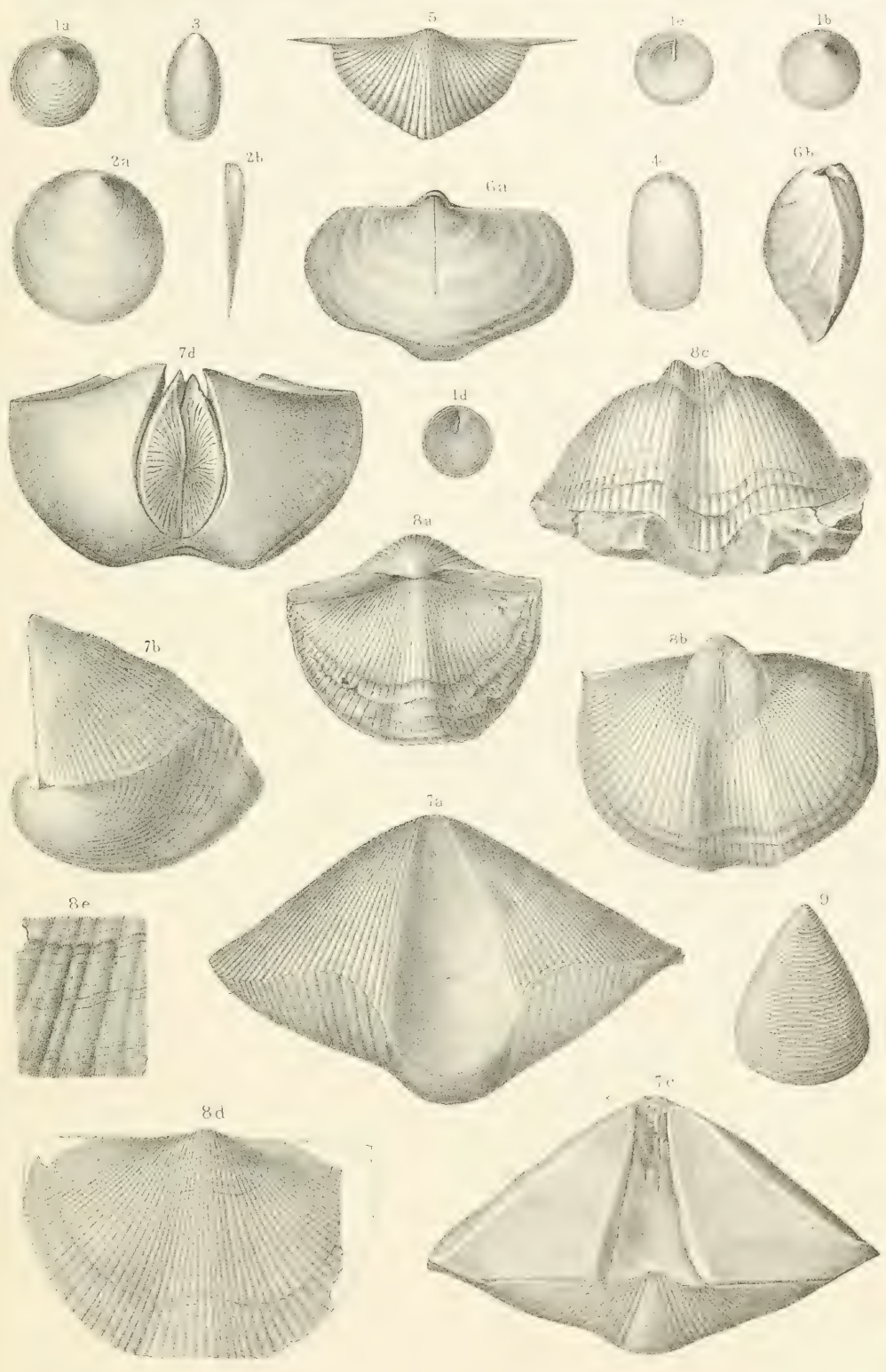


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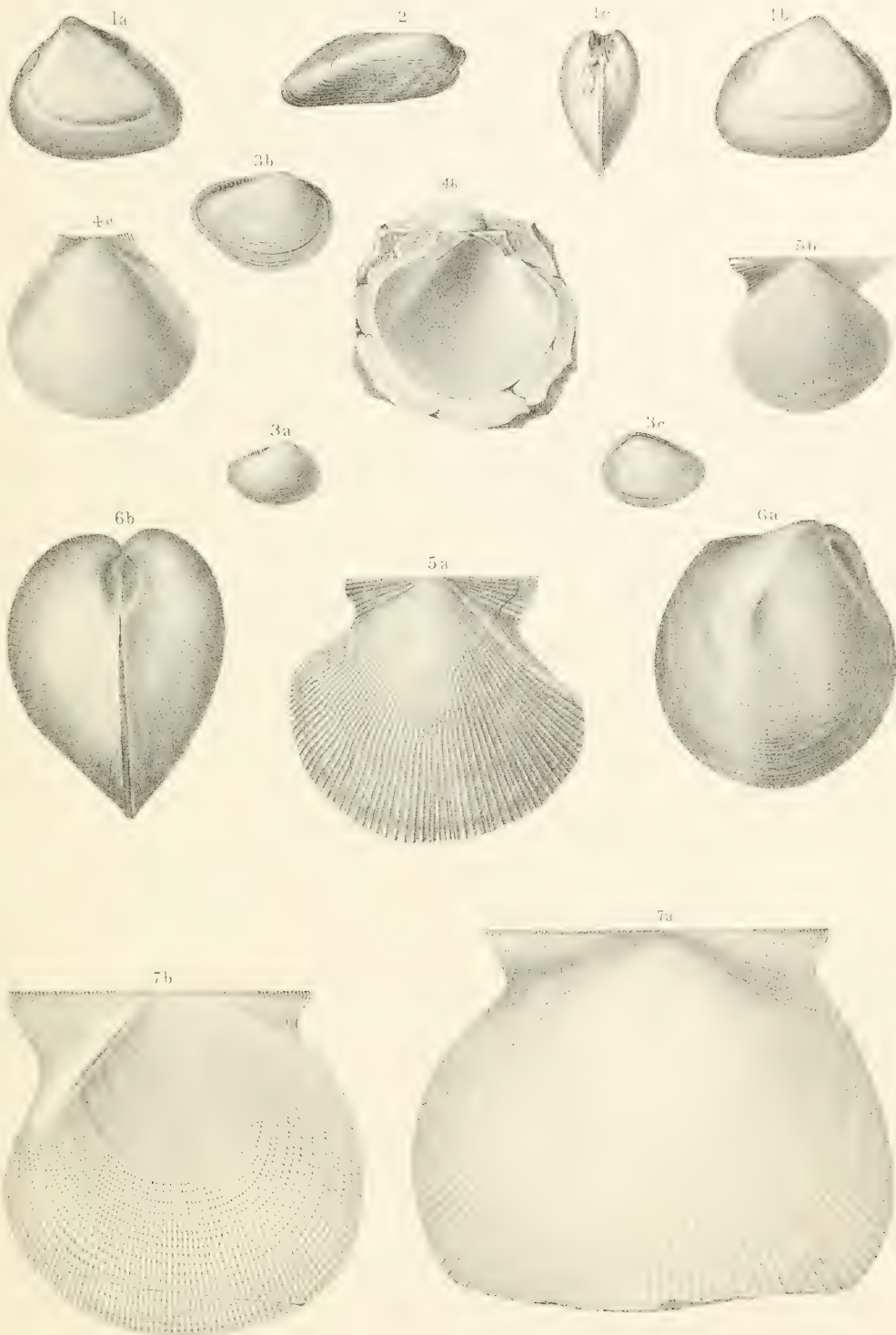


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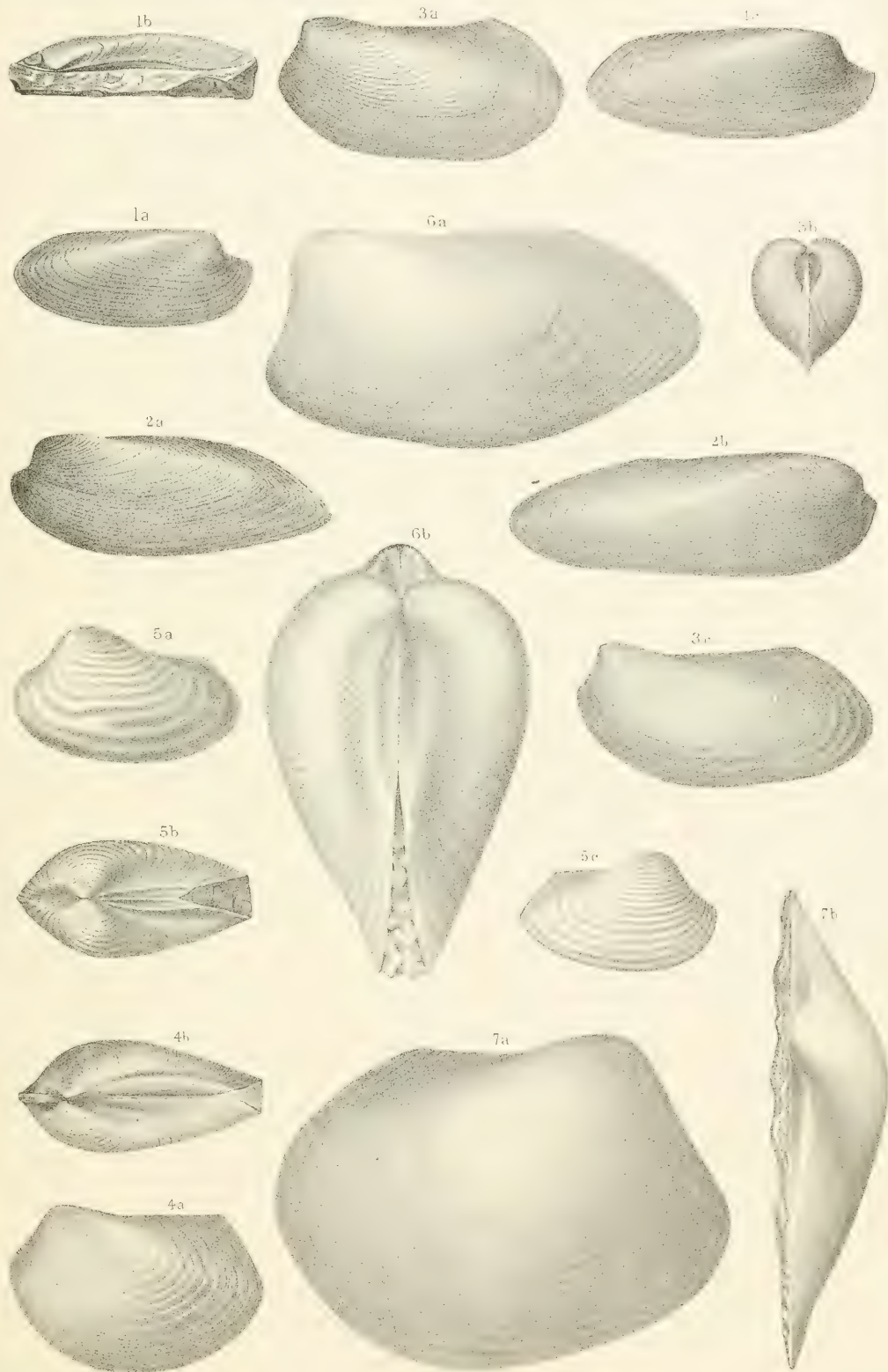


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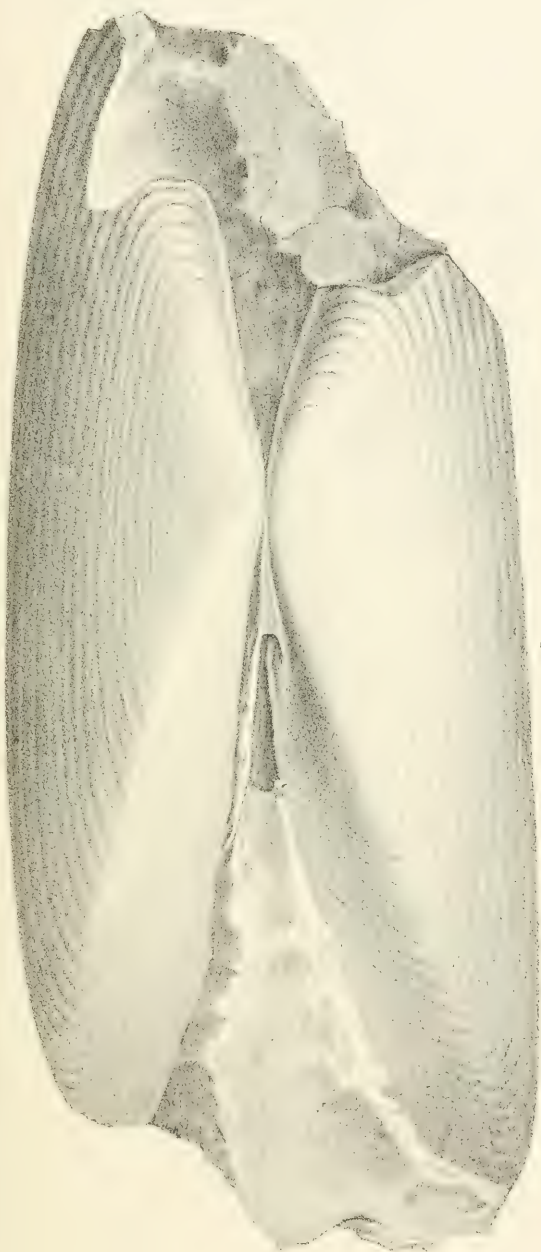


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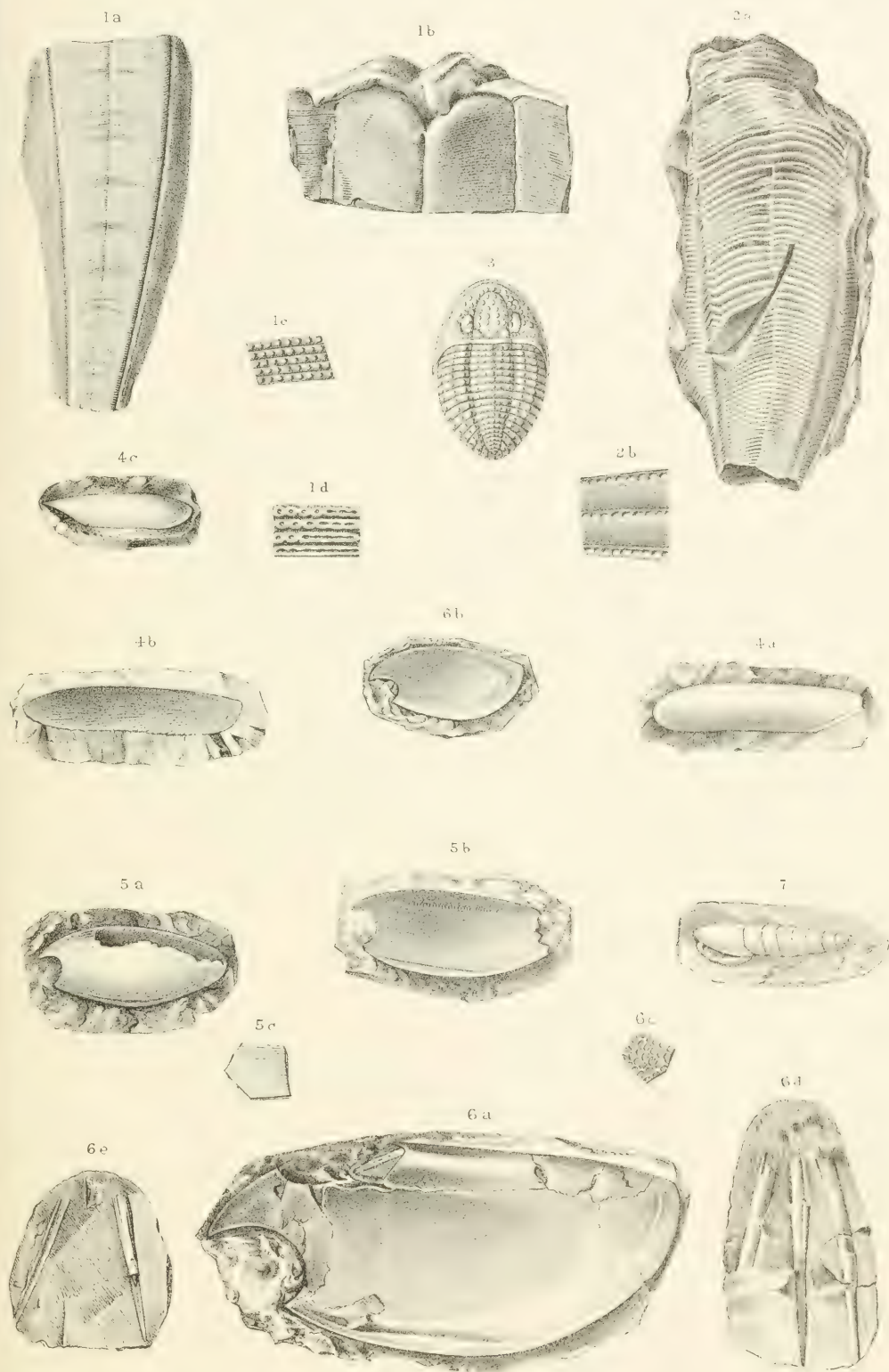


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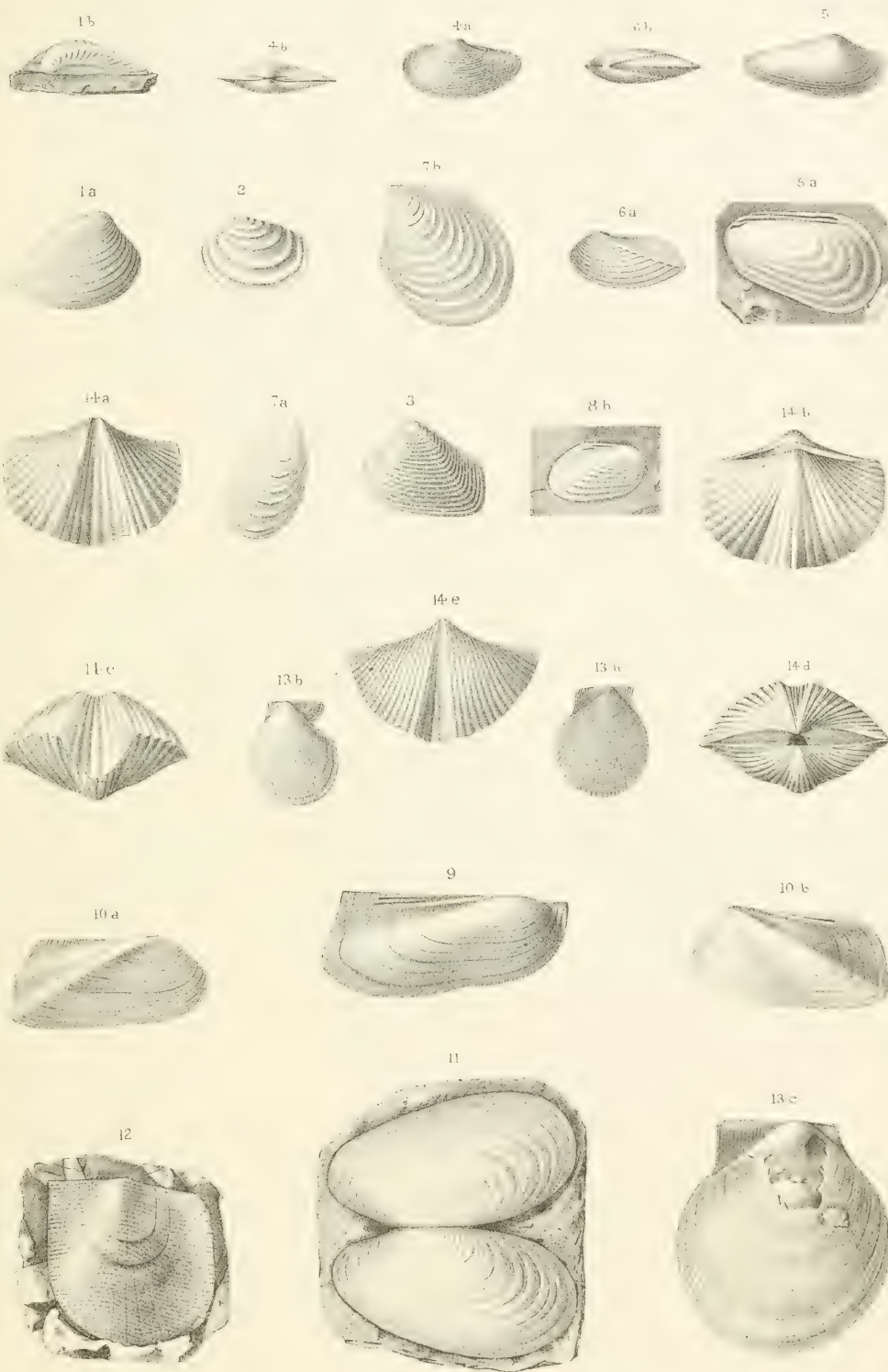


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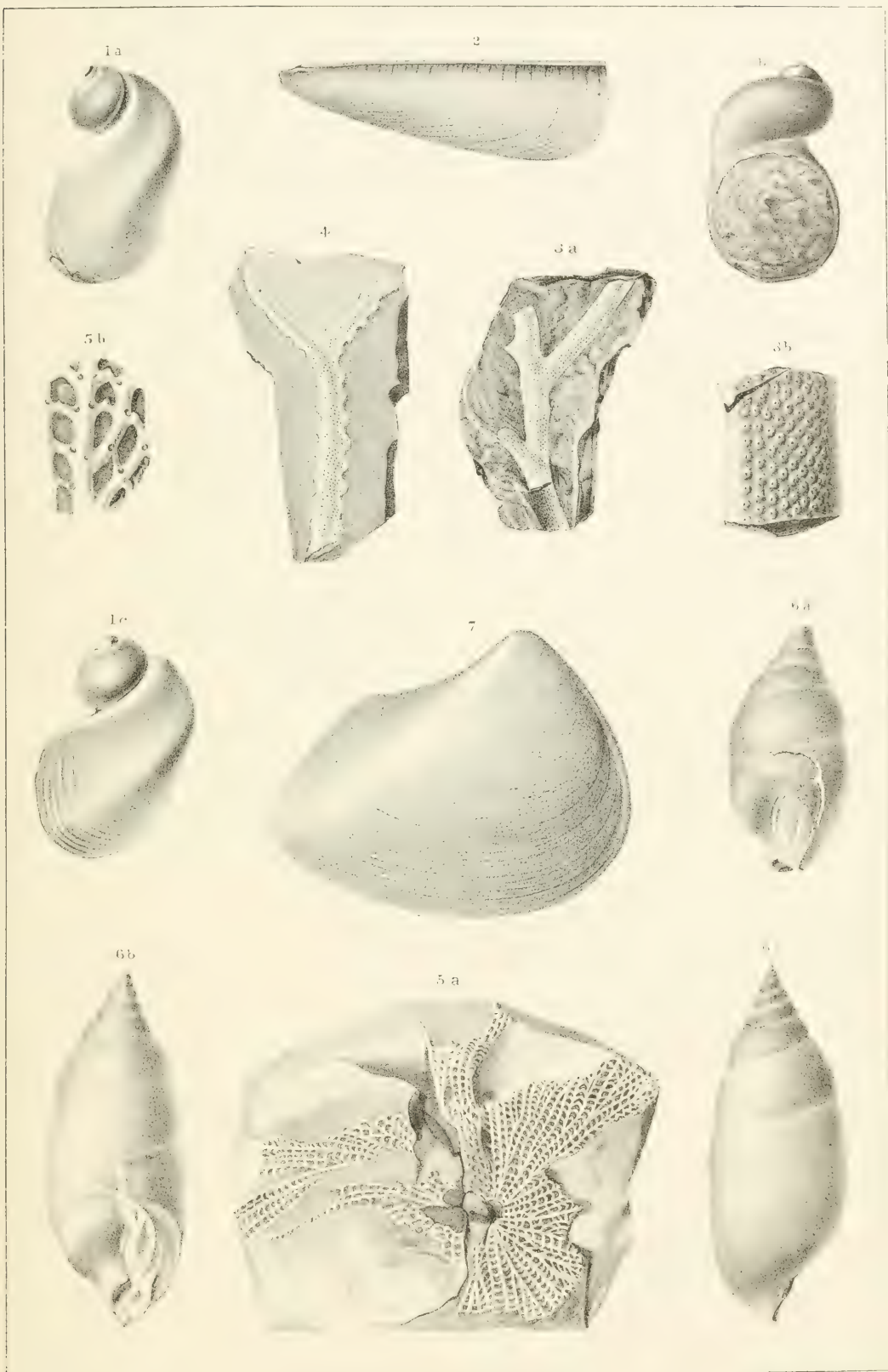


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PL. XXI.

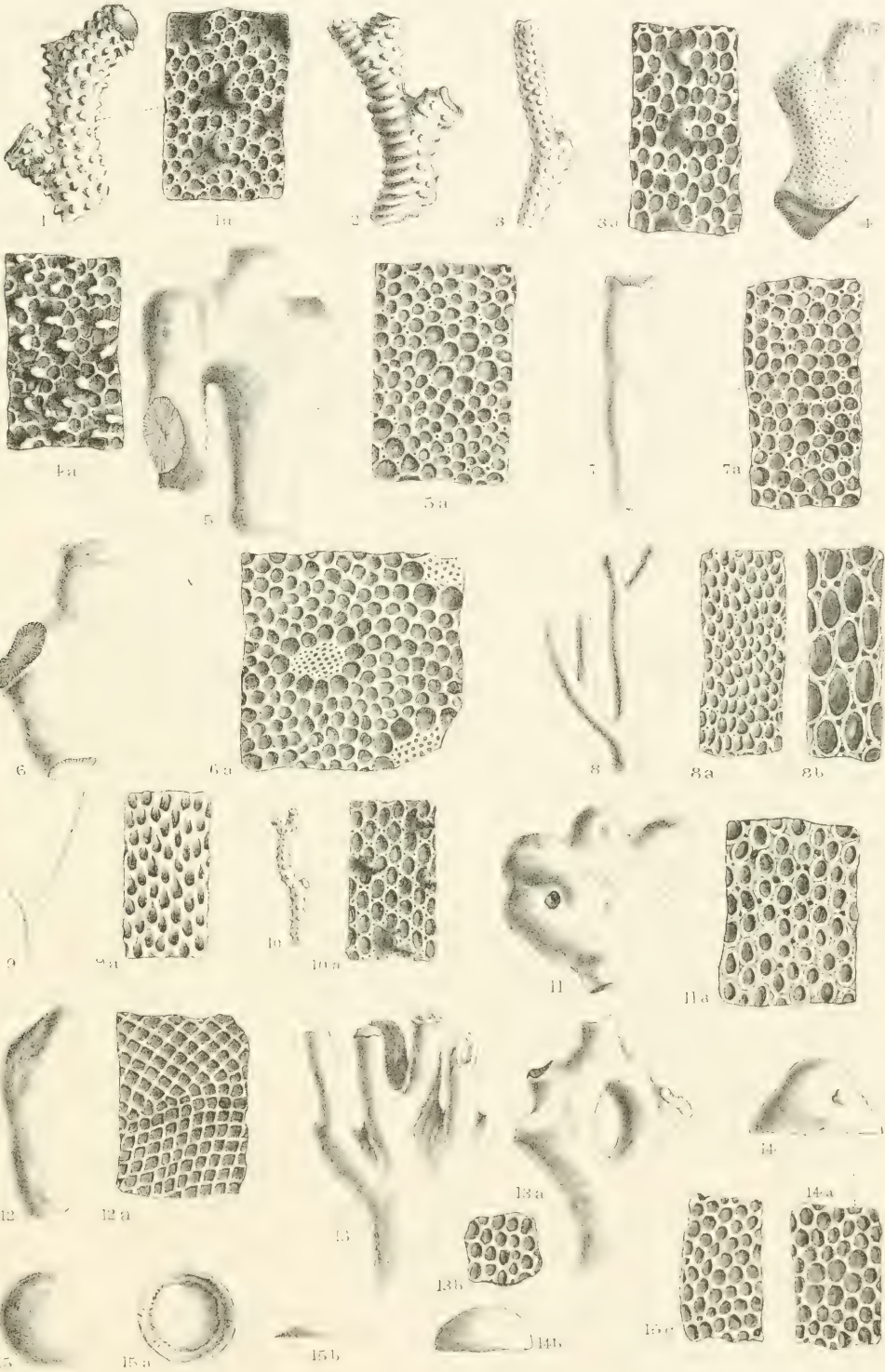
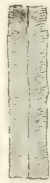


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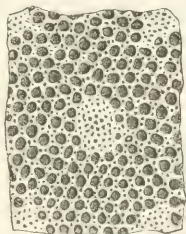
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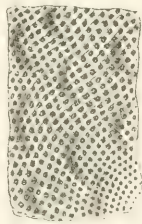
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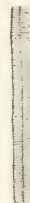
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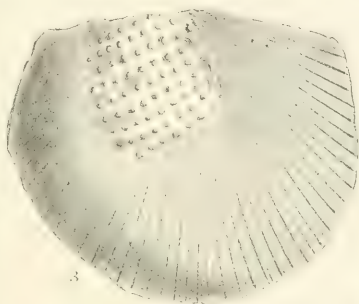
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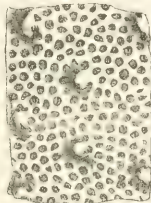
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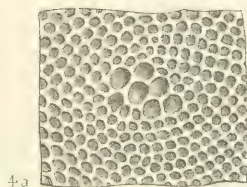
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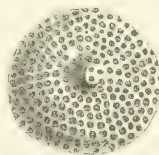
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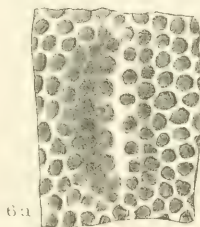
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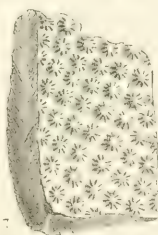
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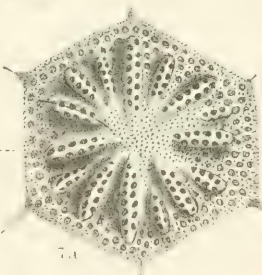
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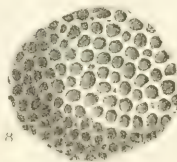
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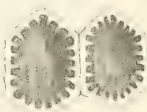
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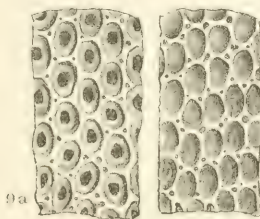
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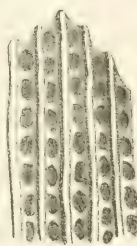
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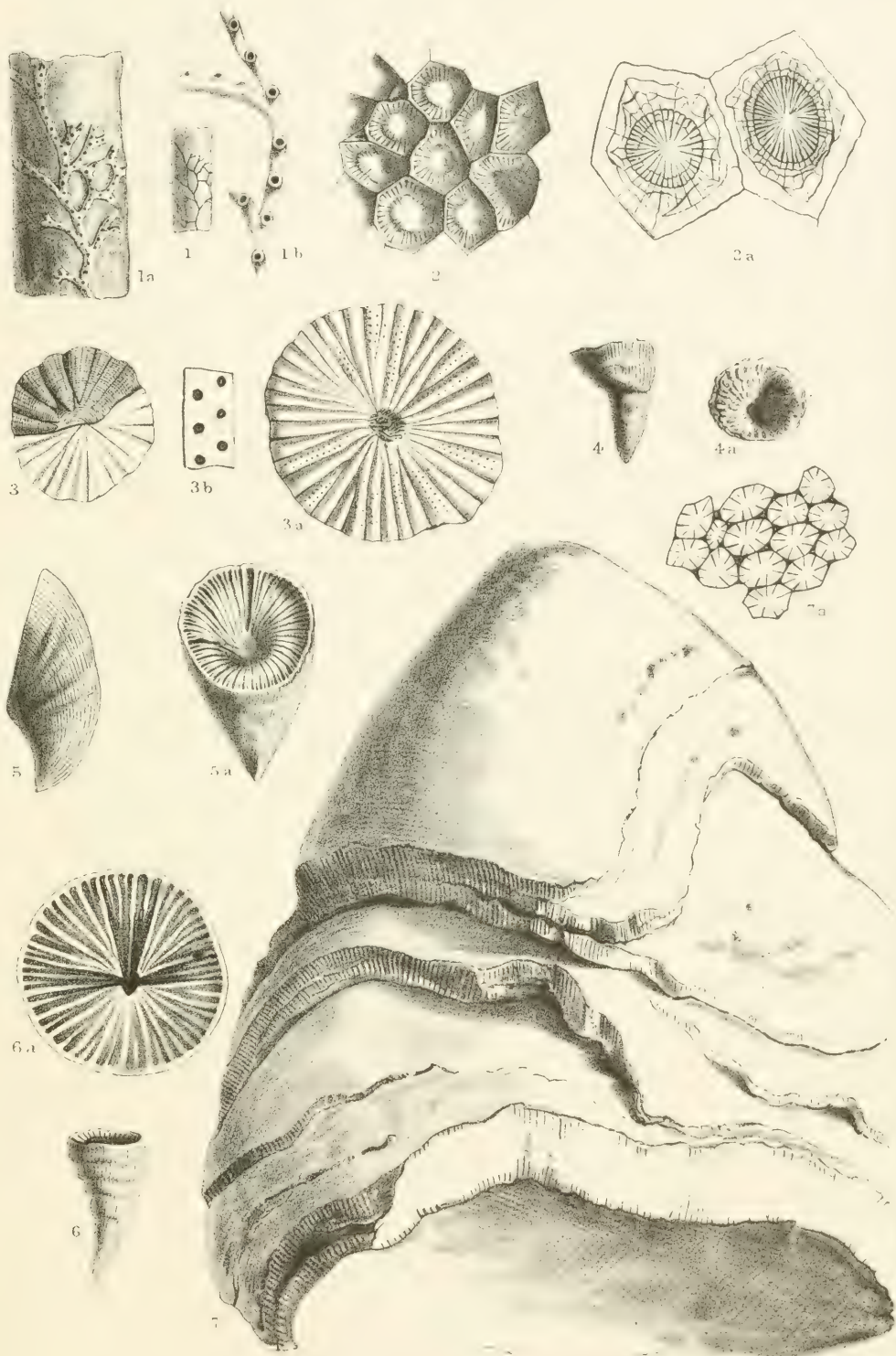
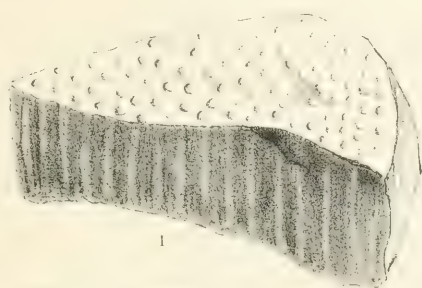
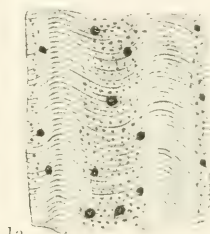


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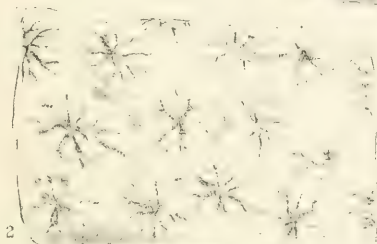
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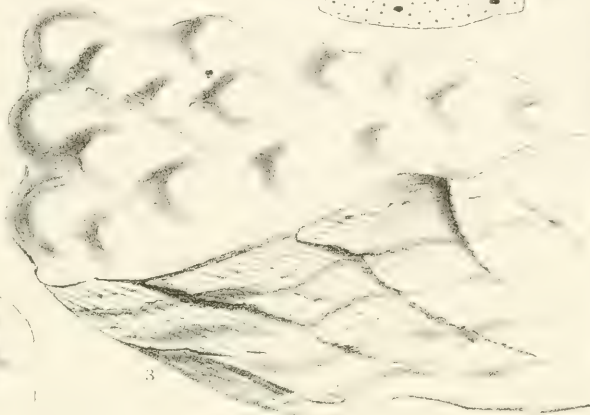
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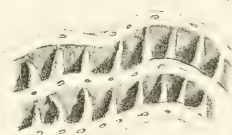
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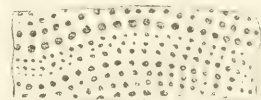
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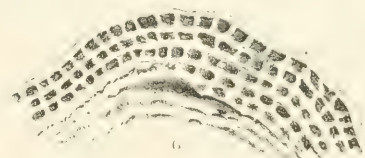
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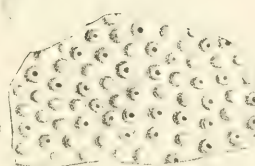
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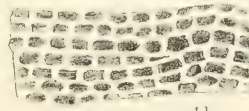
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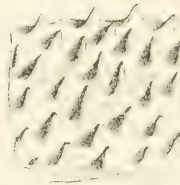
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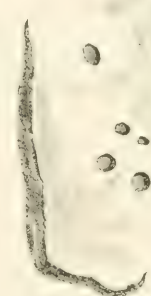
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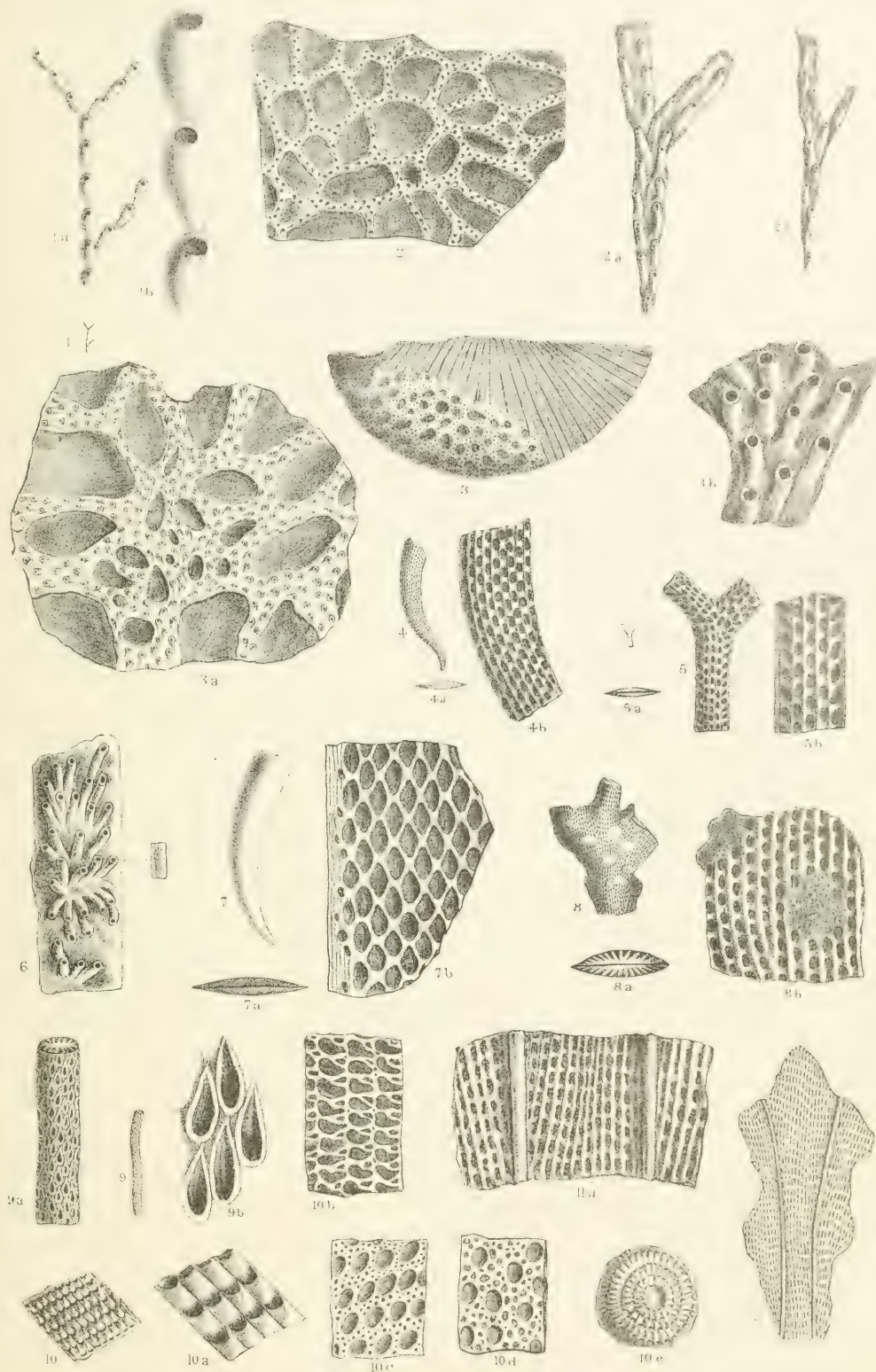
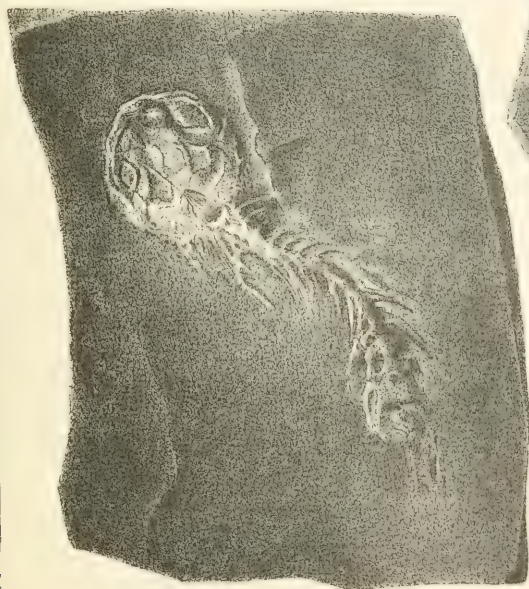
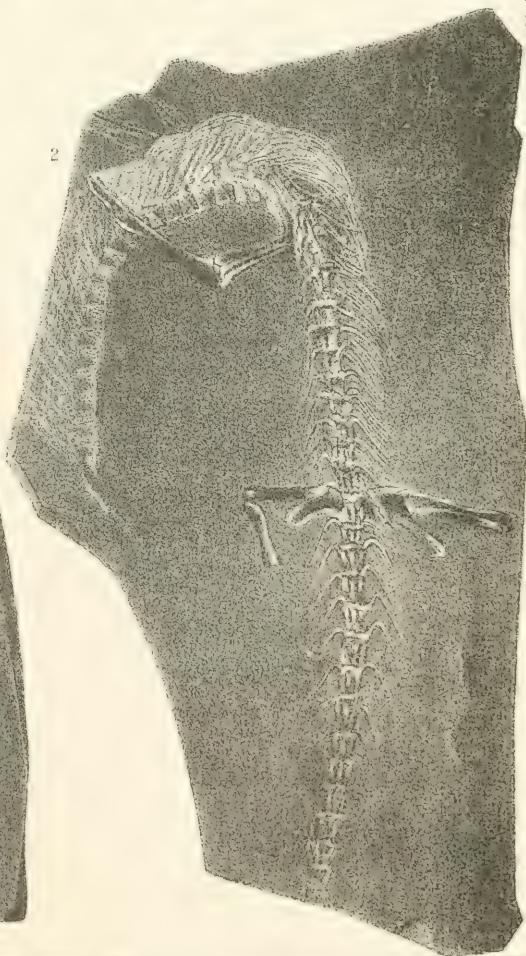


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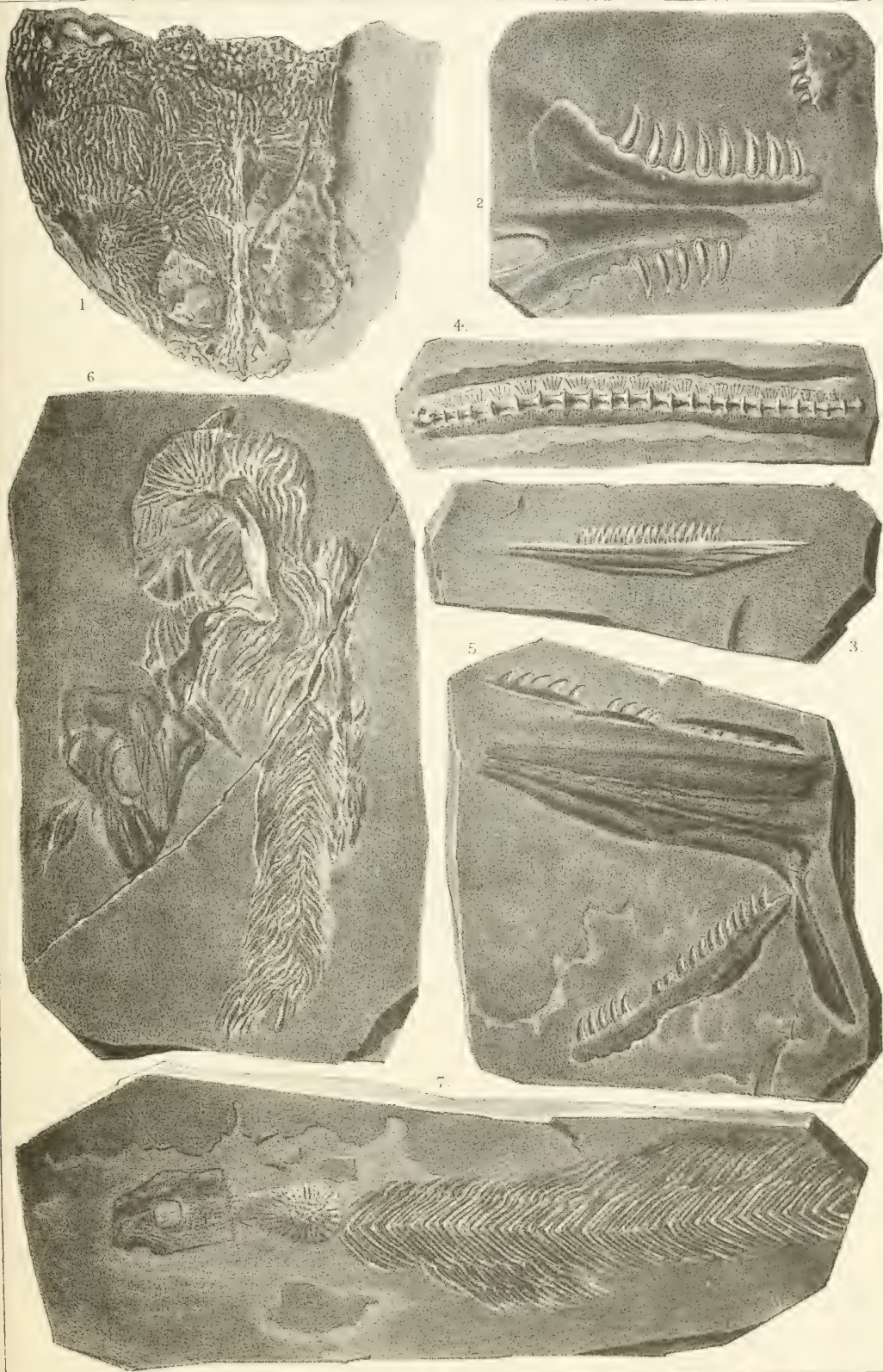
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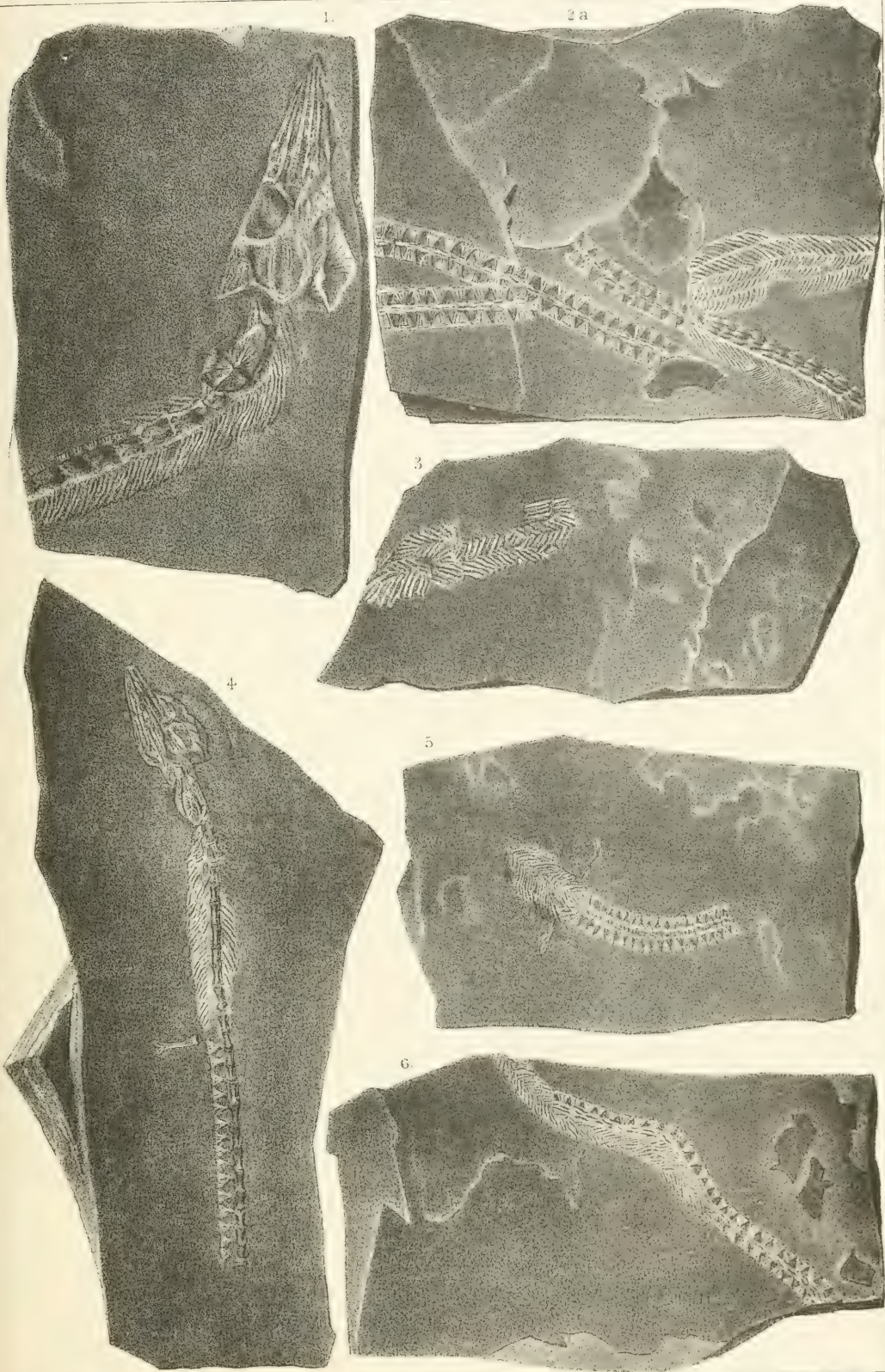
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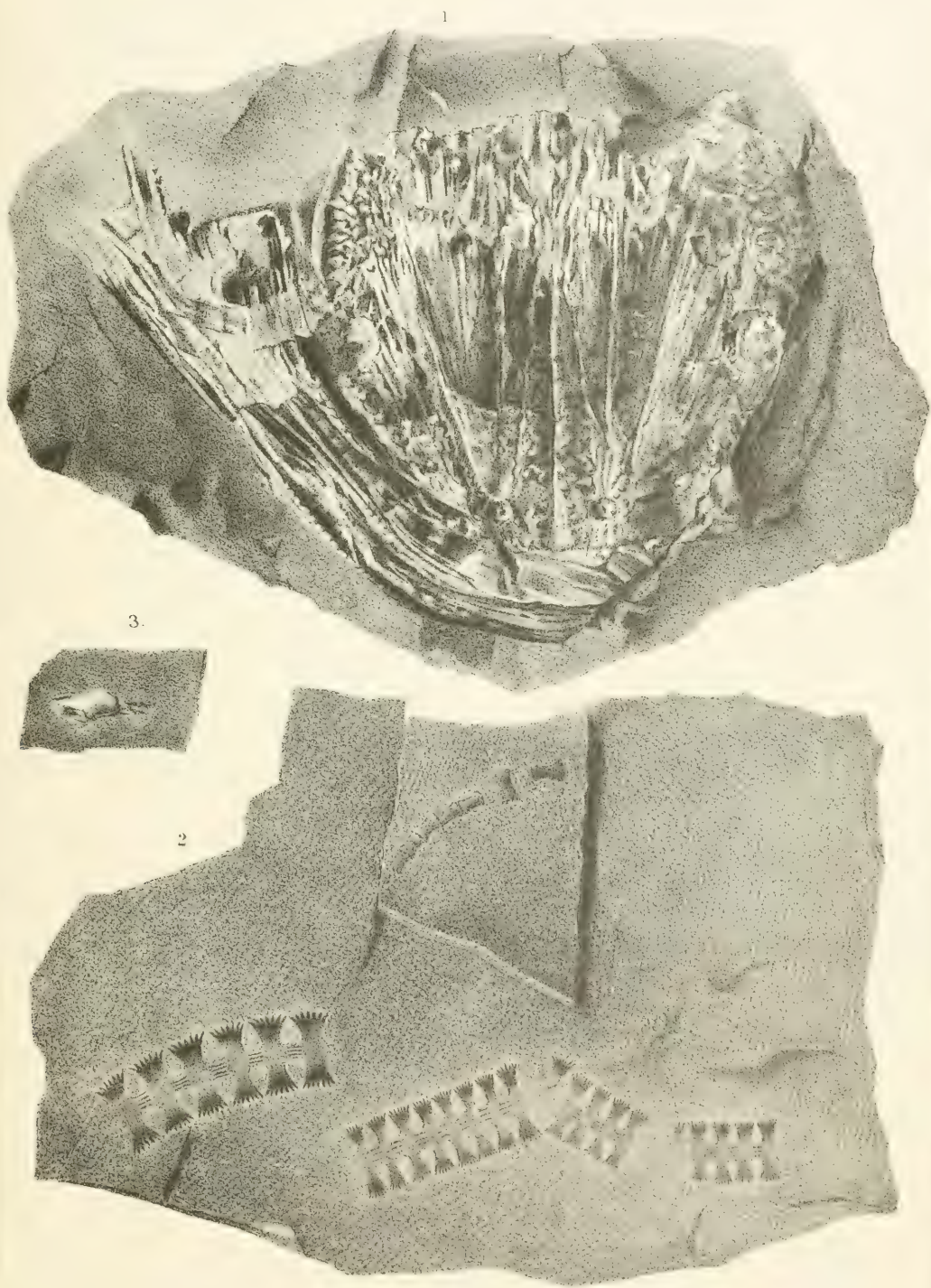
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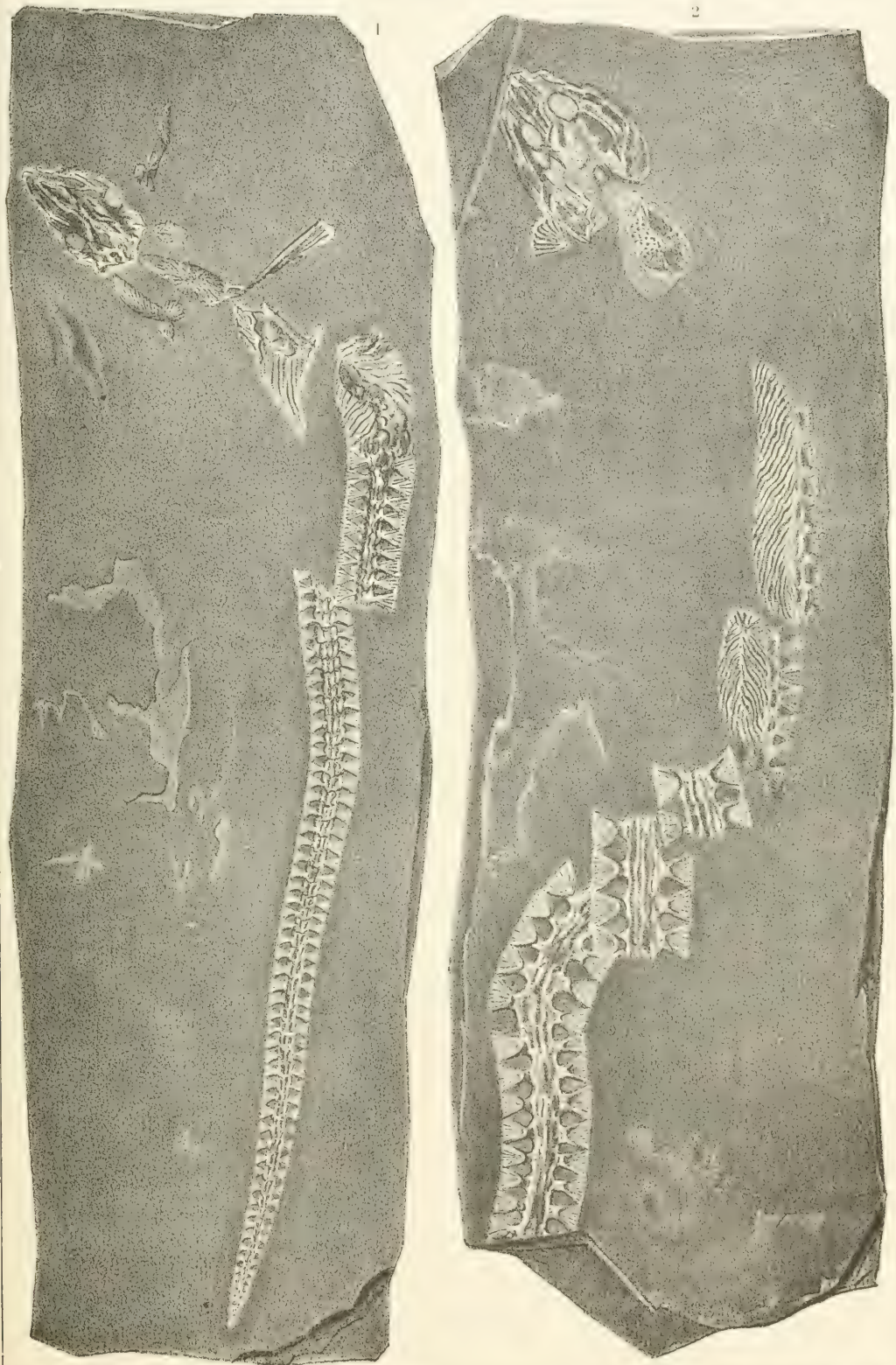
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Geological Survey of Ohio,

CARBONIFEROUS.

(Coal Measures.).

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Thos. Sinclair & Son Lith. Phila.

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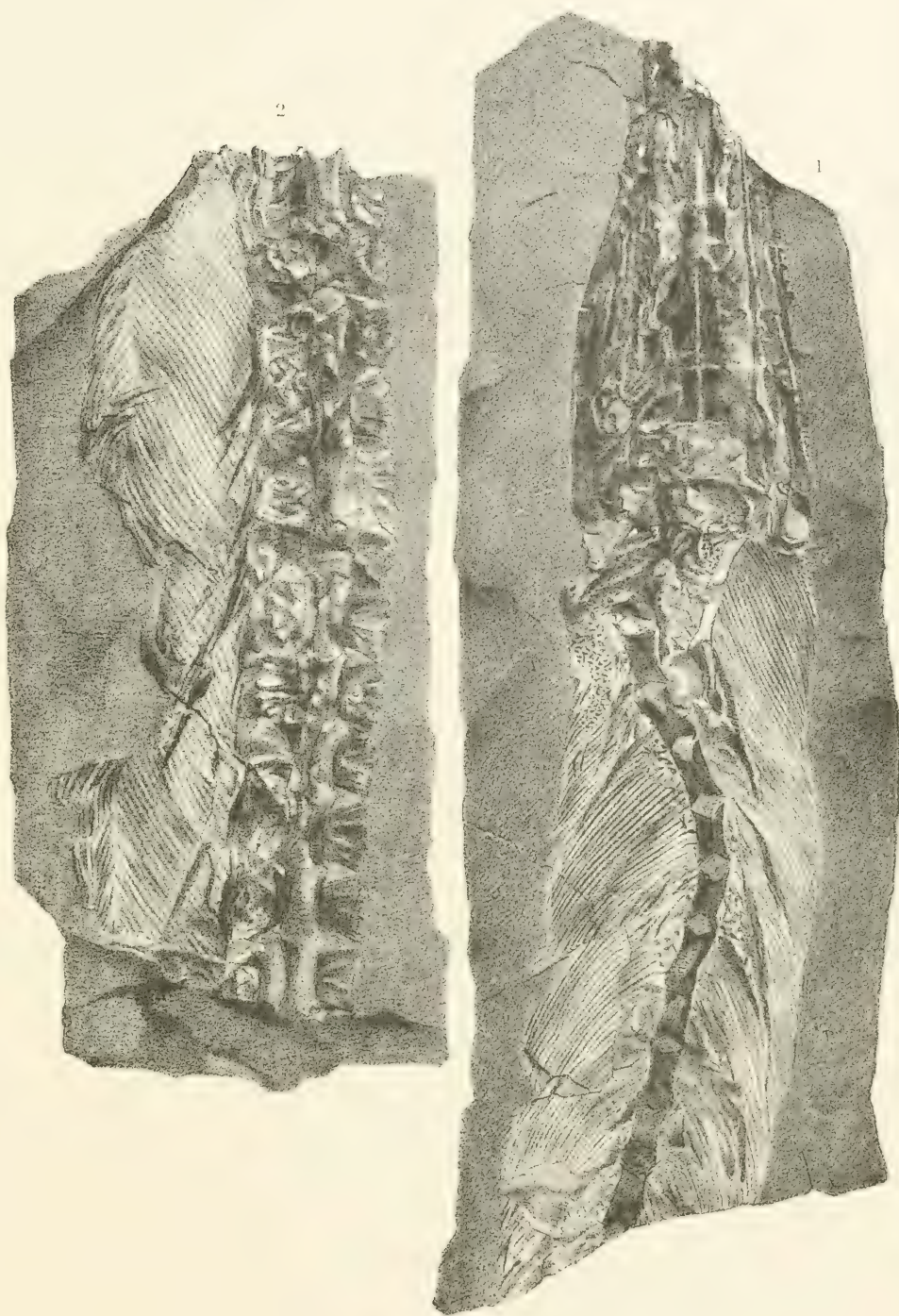
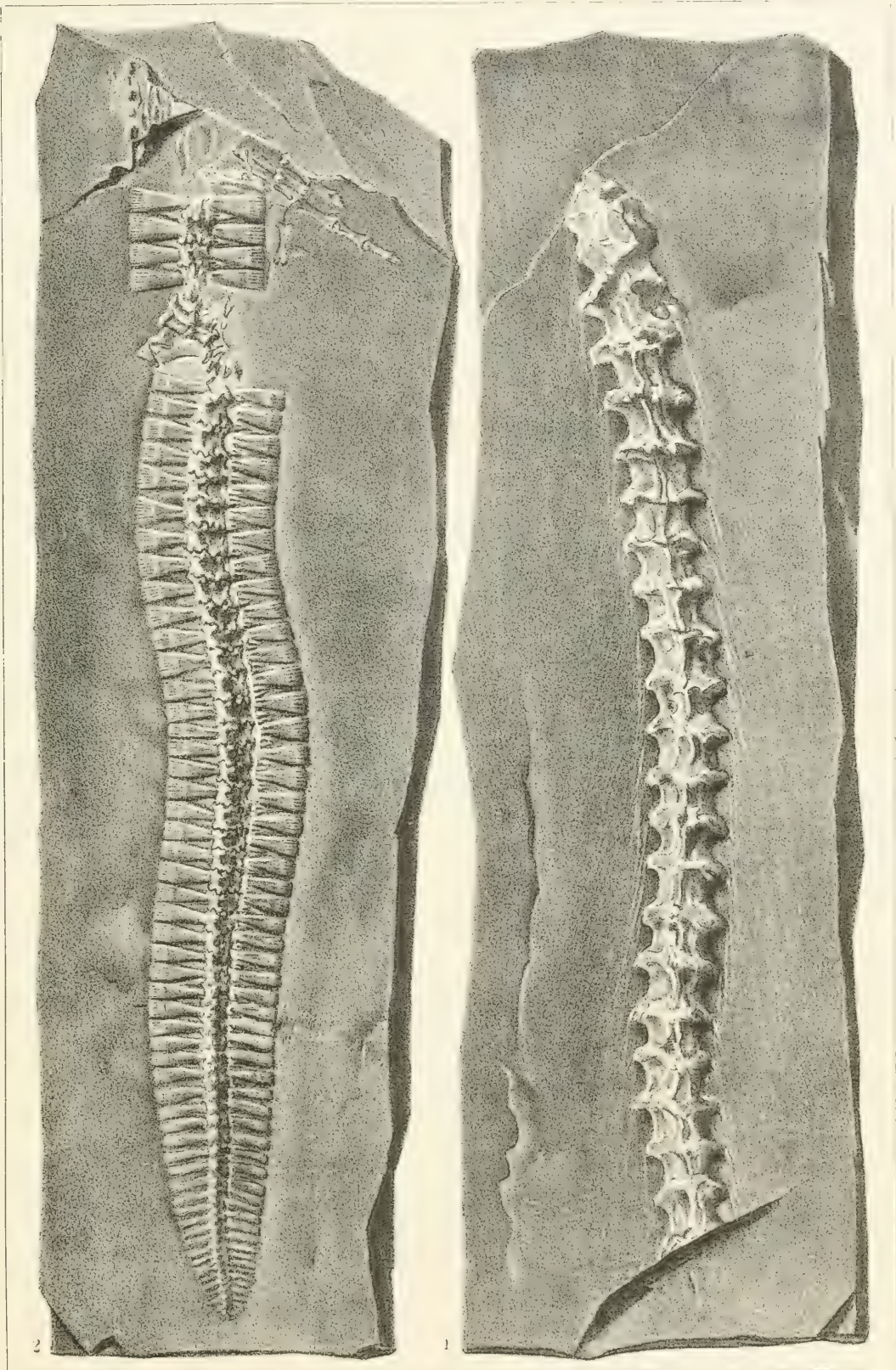


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LEPELGETHIX SERPENS. 2 D. IS. COPELAND. S. H. M. 1877.

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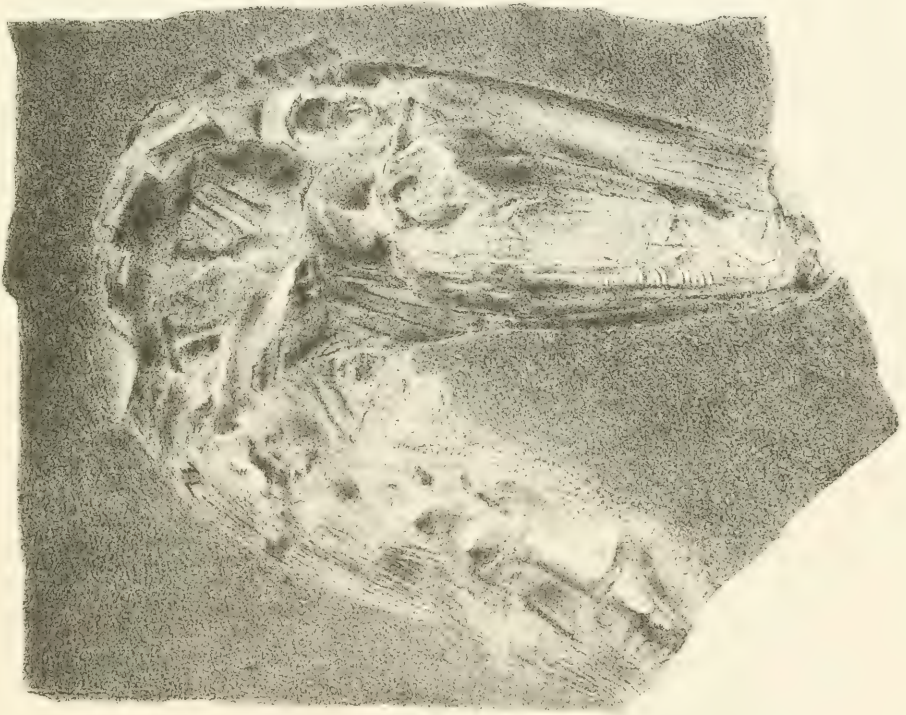


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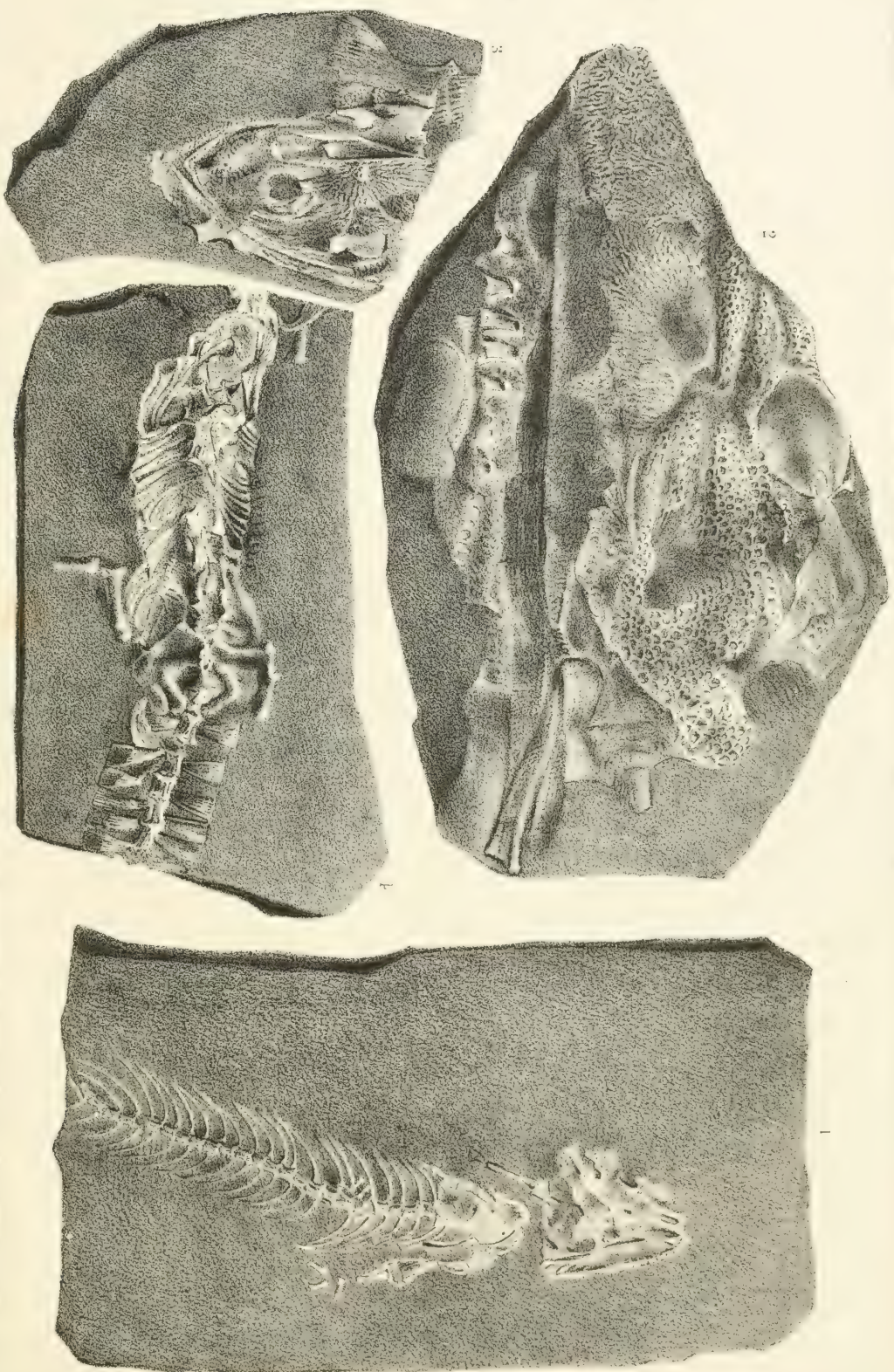
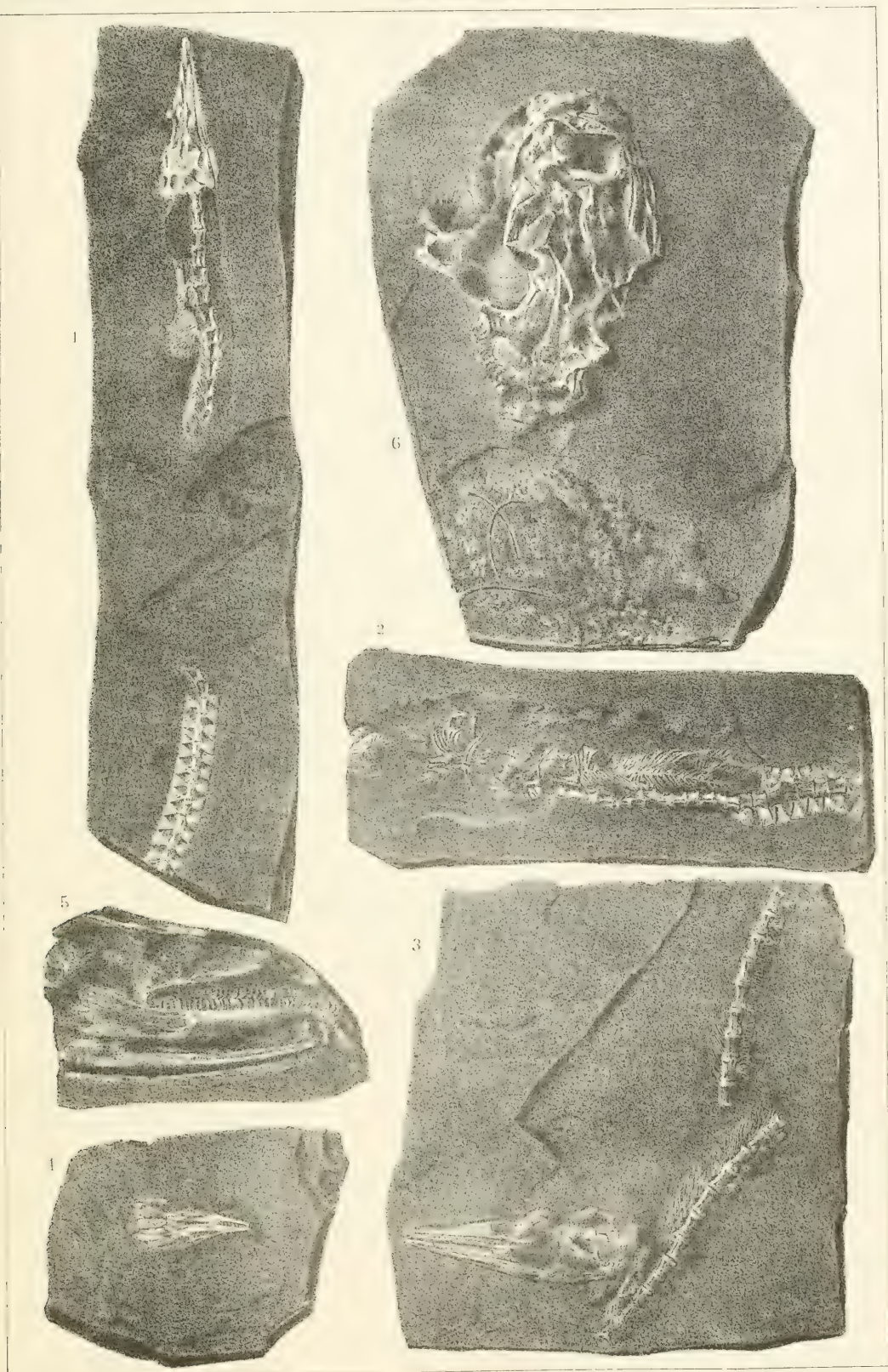


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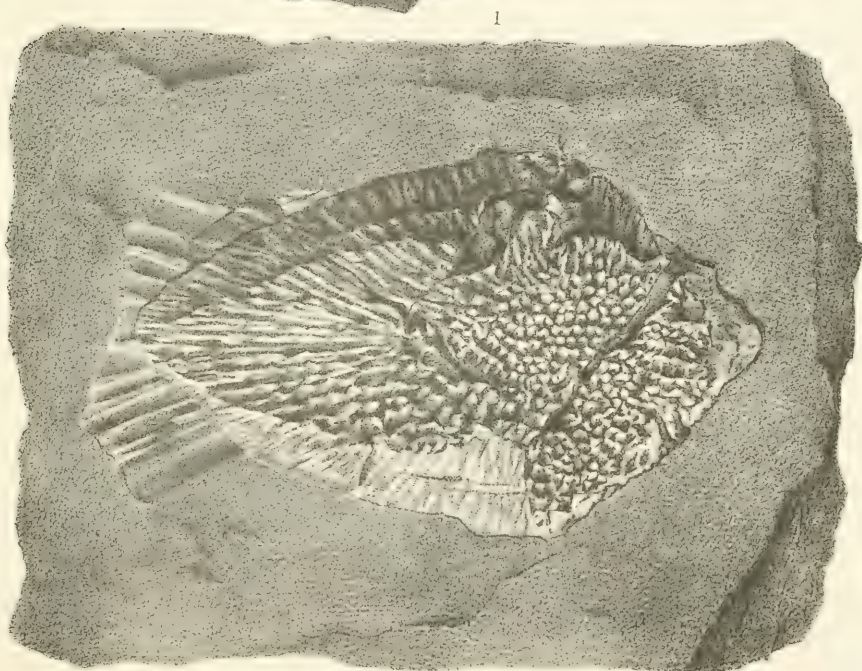
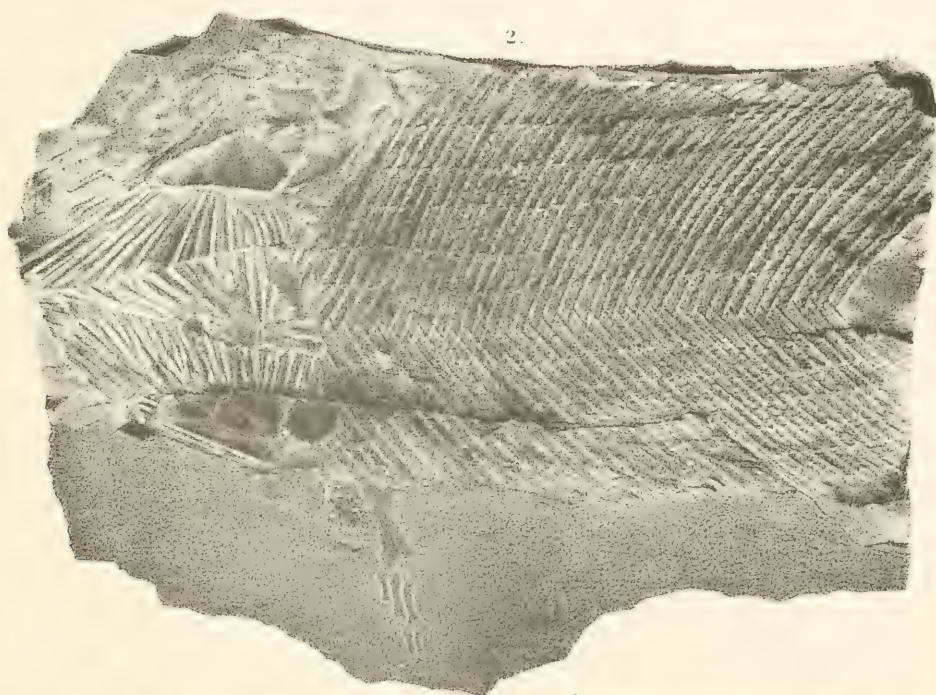


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1. *PTYONIUS PECTINATUS*. 4. *PTYONIUS*.
5. *OESTOCEPHALUS*. 6. *PEPLORHINA ANTERACINA*.

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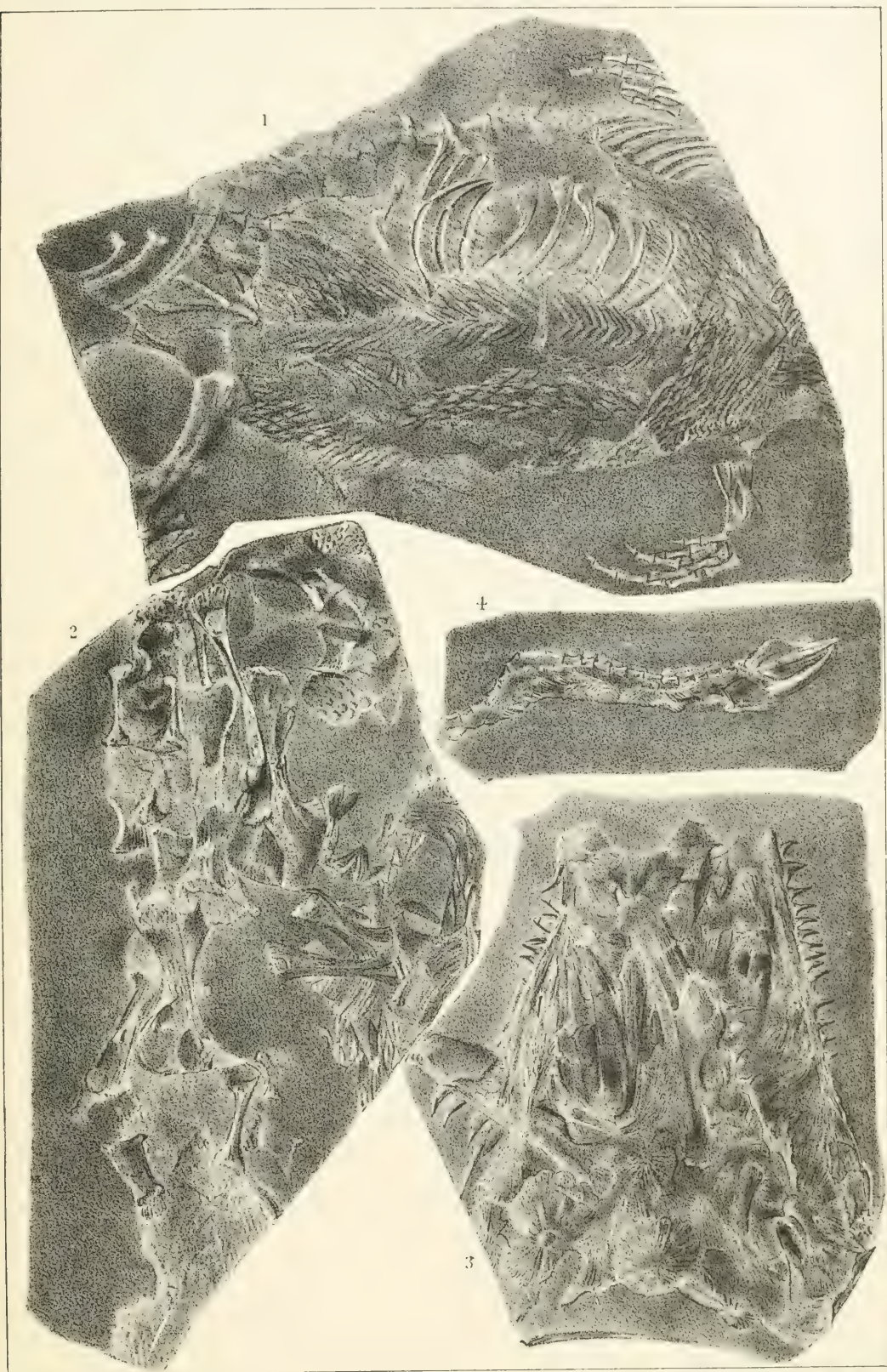
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J. S. Sinclair & Son, Lith. Phila.

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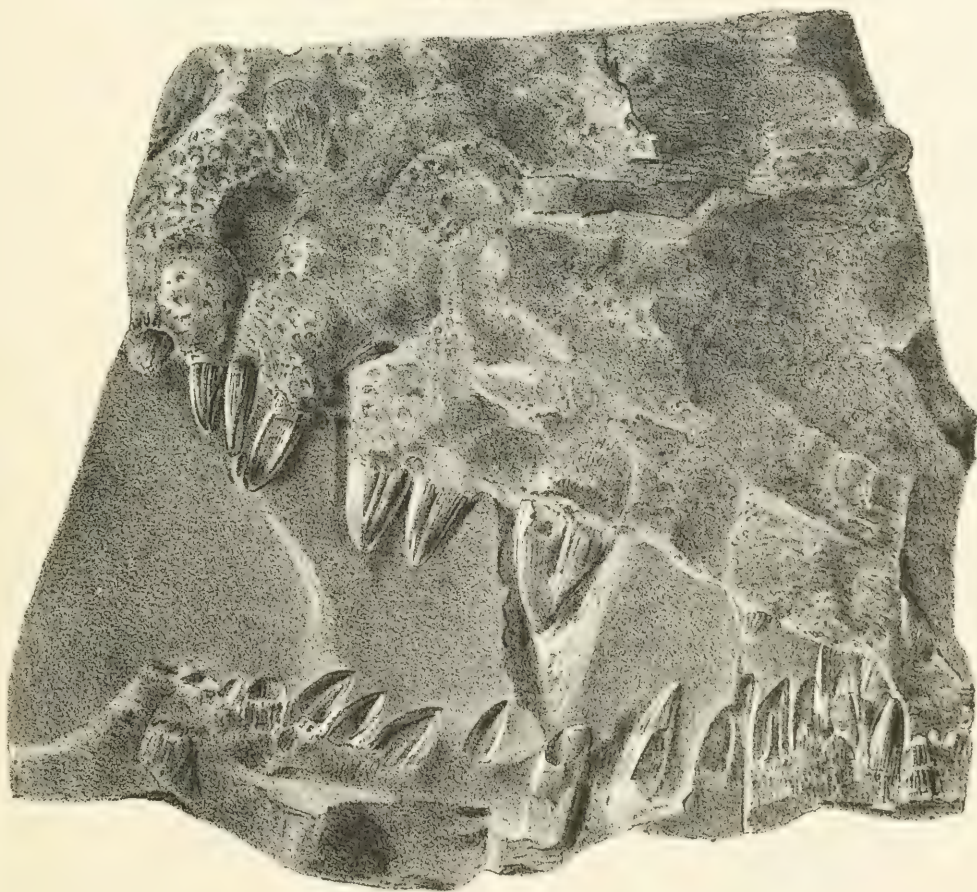


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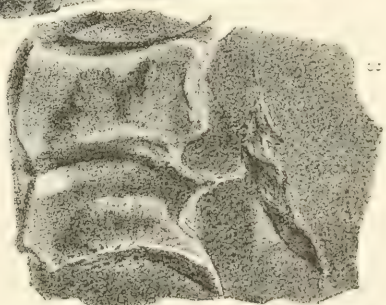
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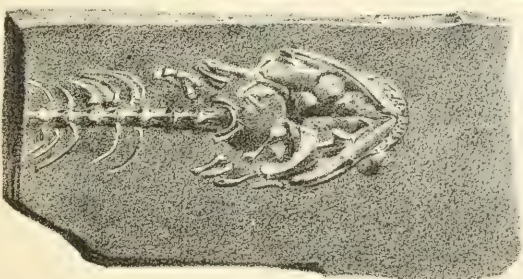
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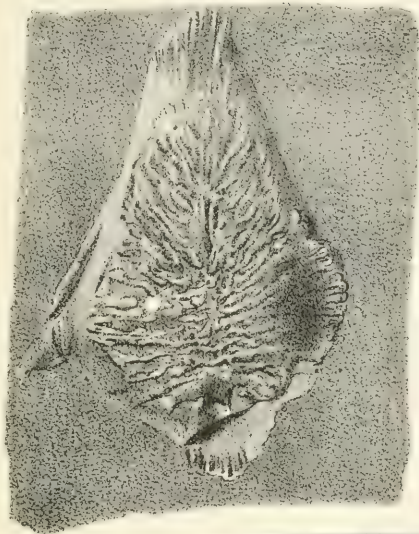
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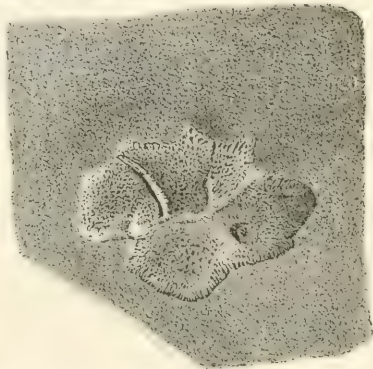
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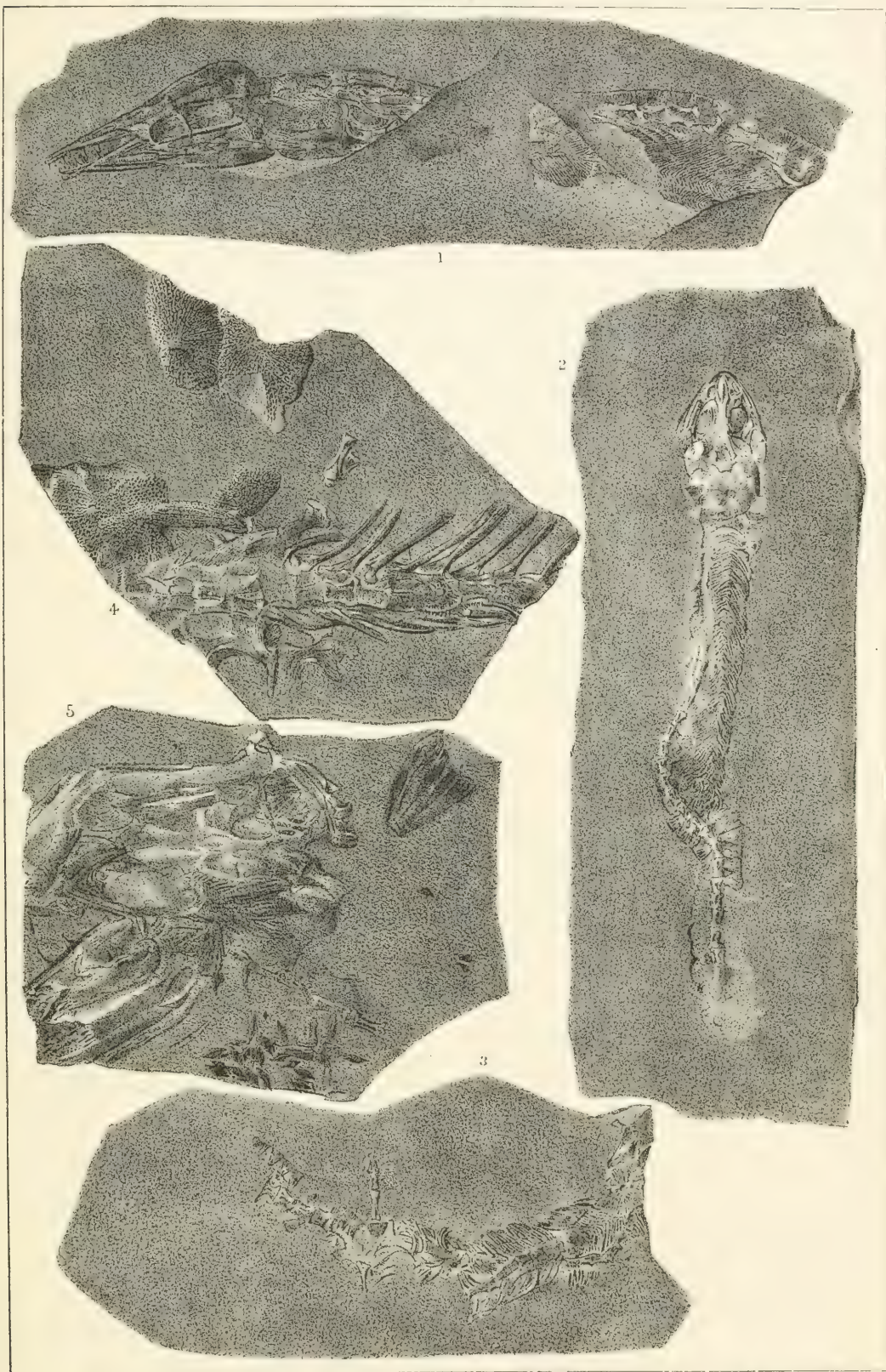
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1-2. COLOSTEUS PAUCIRADIATUS.

4. EURYTHORAX SUBLAEVIS. 5. THORACIC SHIELDS.

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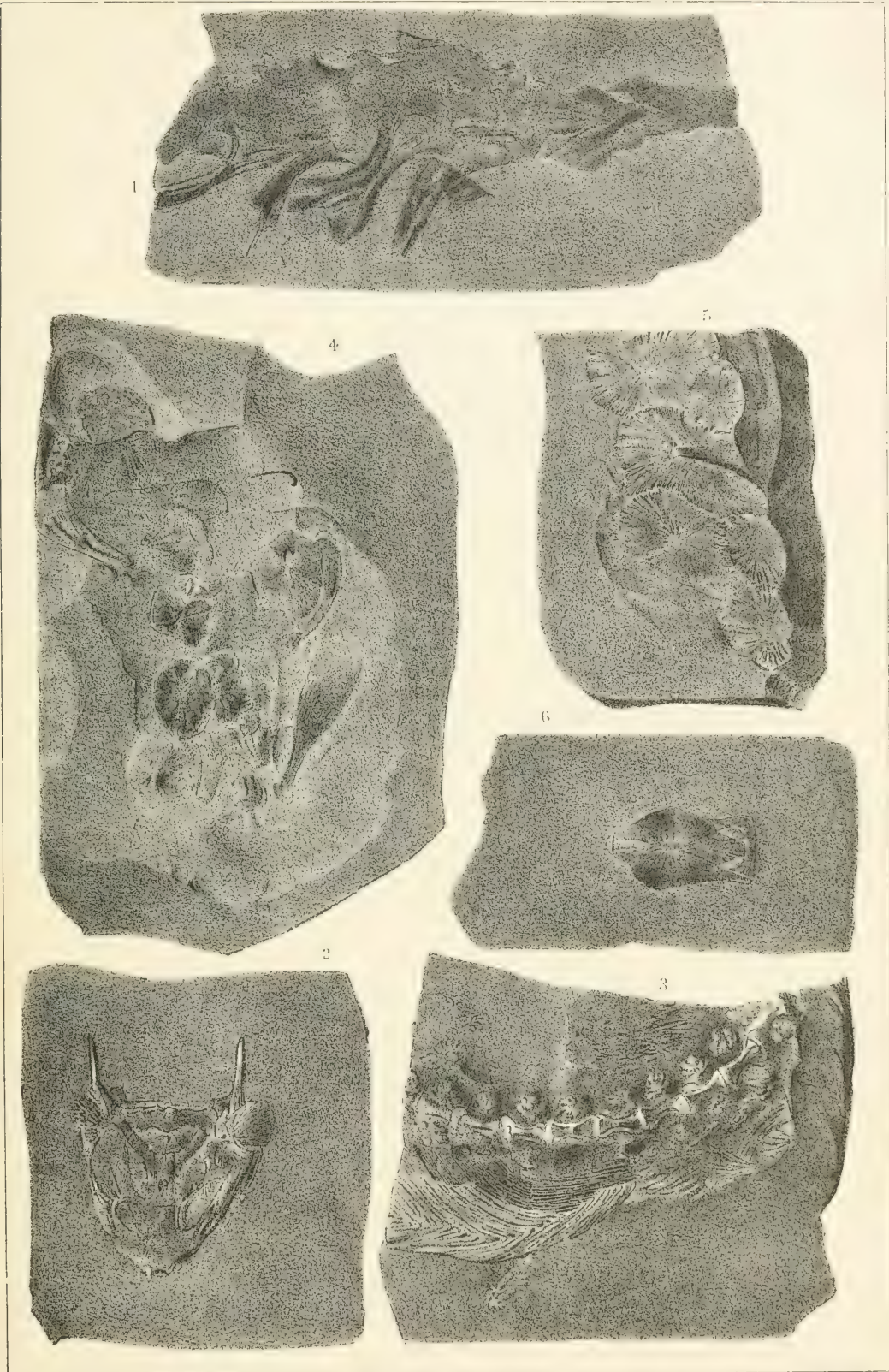
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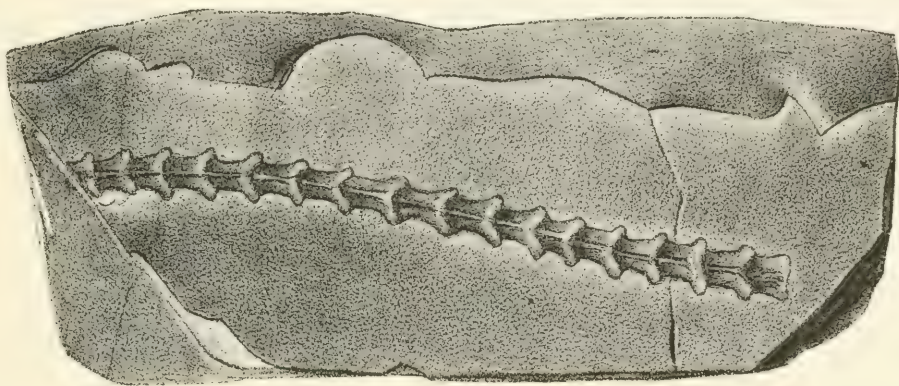
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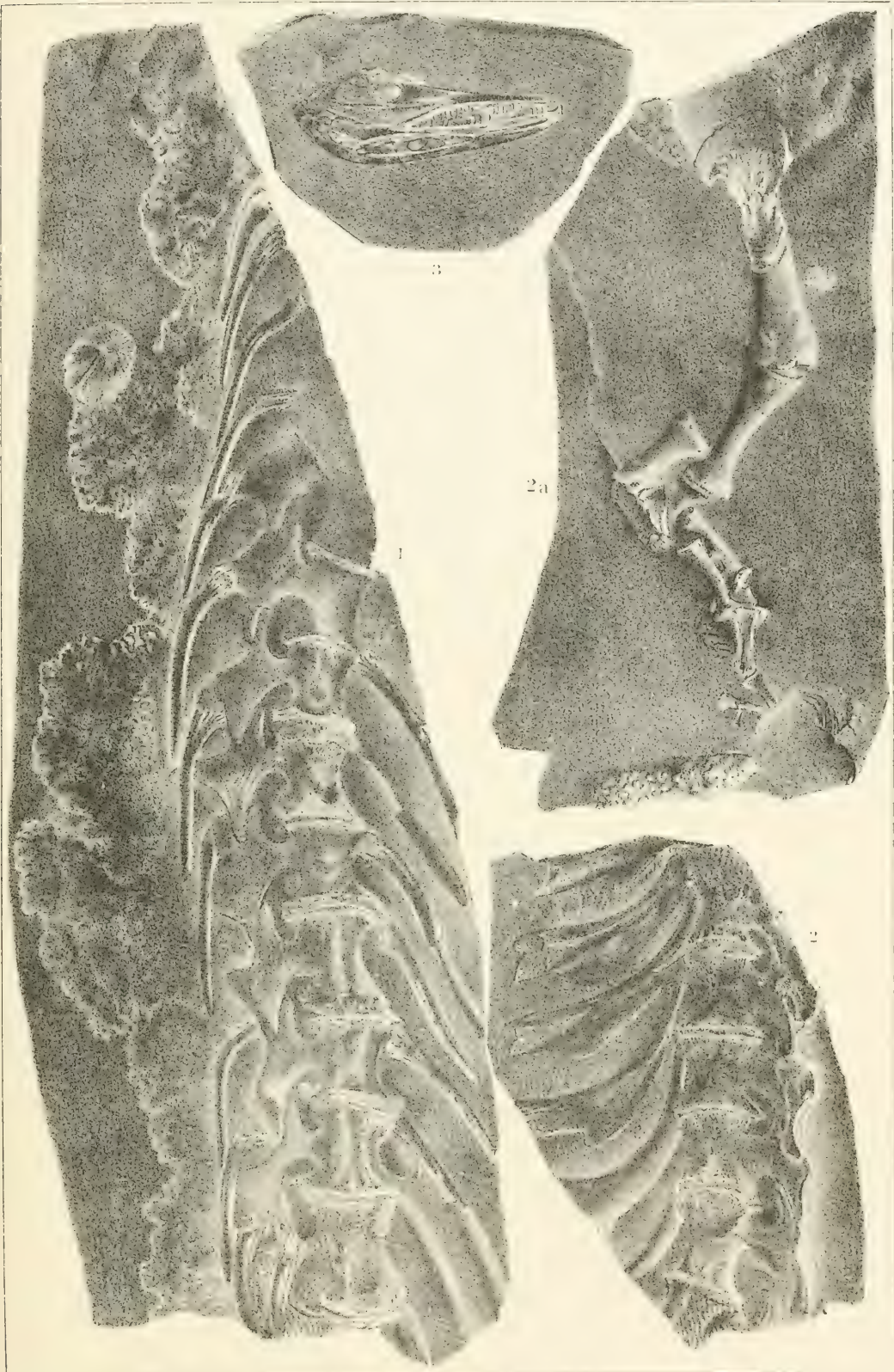


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1. *PHLEGETHONTIA LINEARIS*. 3. *MOLGOPHUS MACRURUS*.

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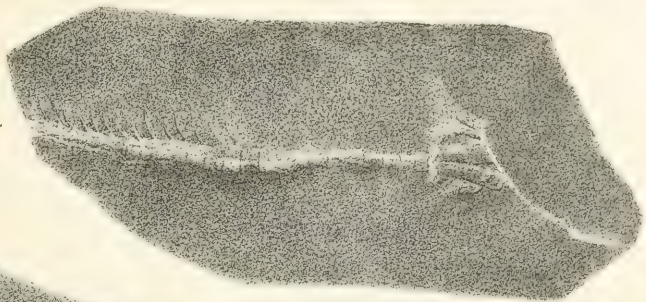
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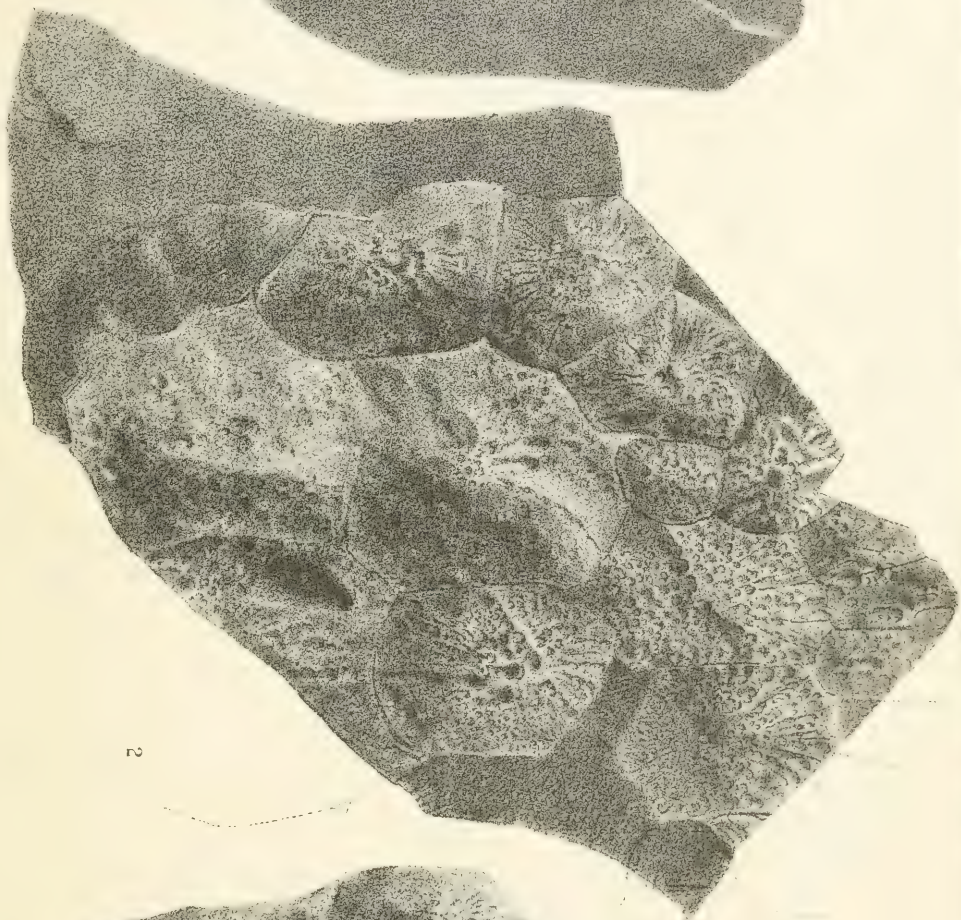
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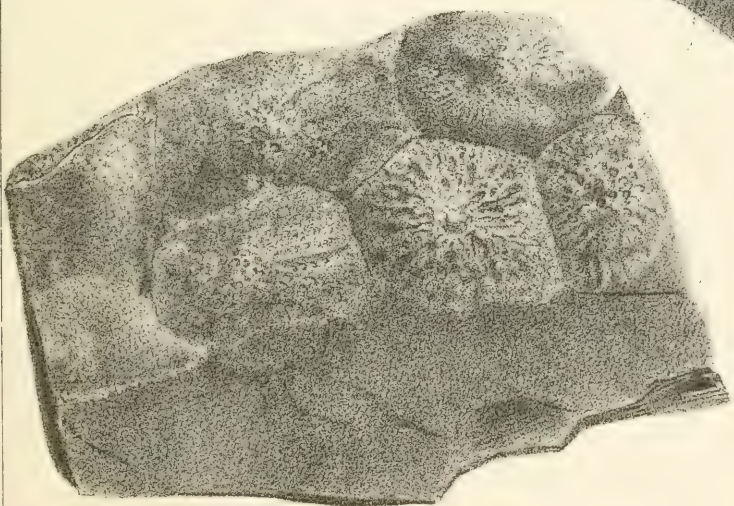


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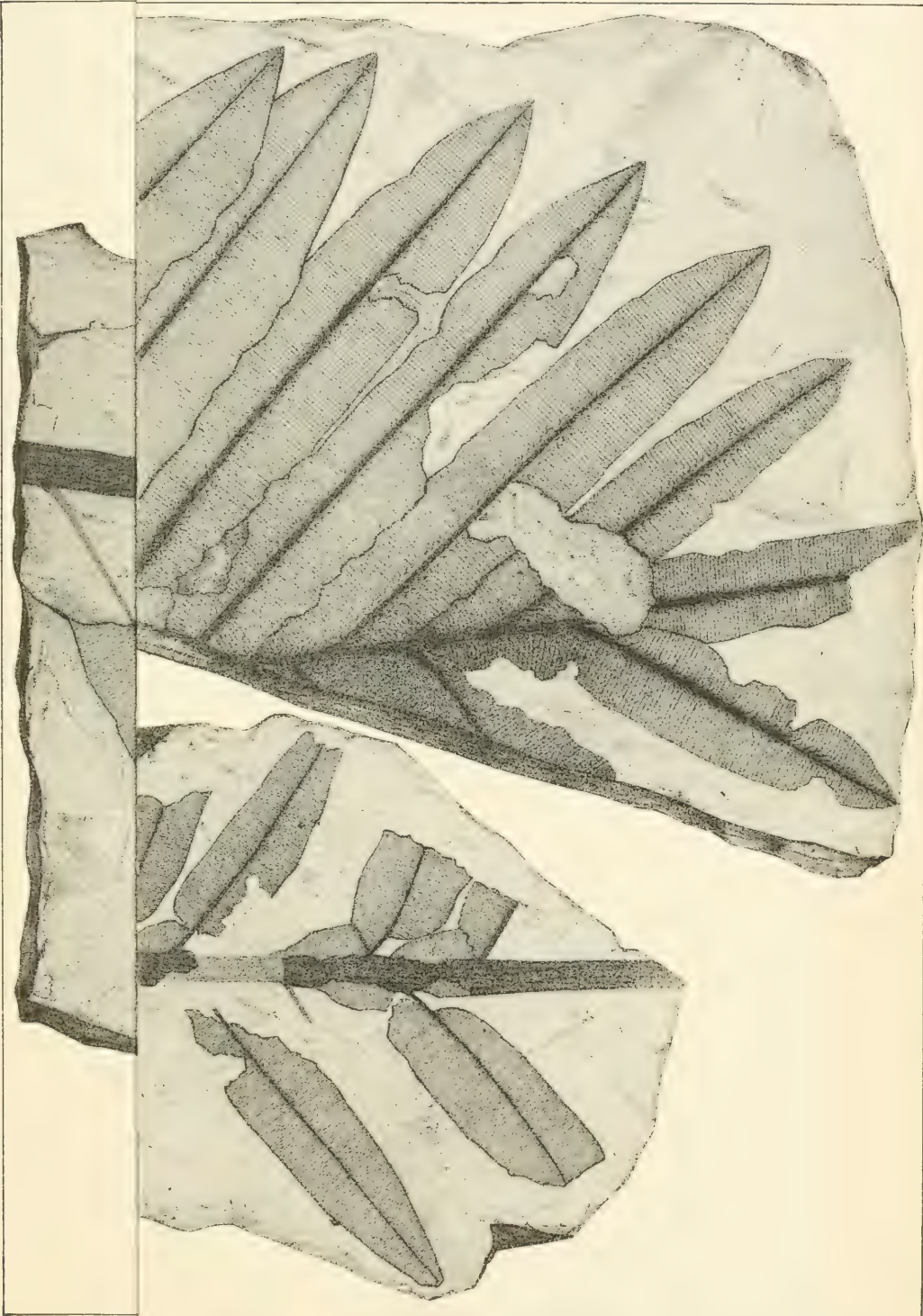
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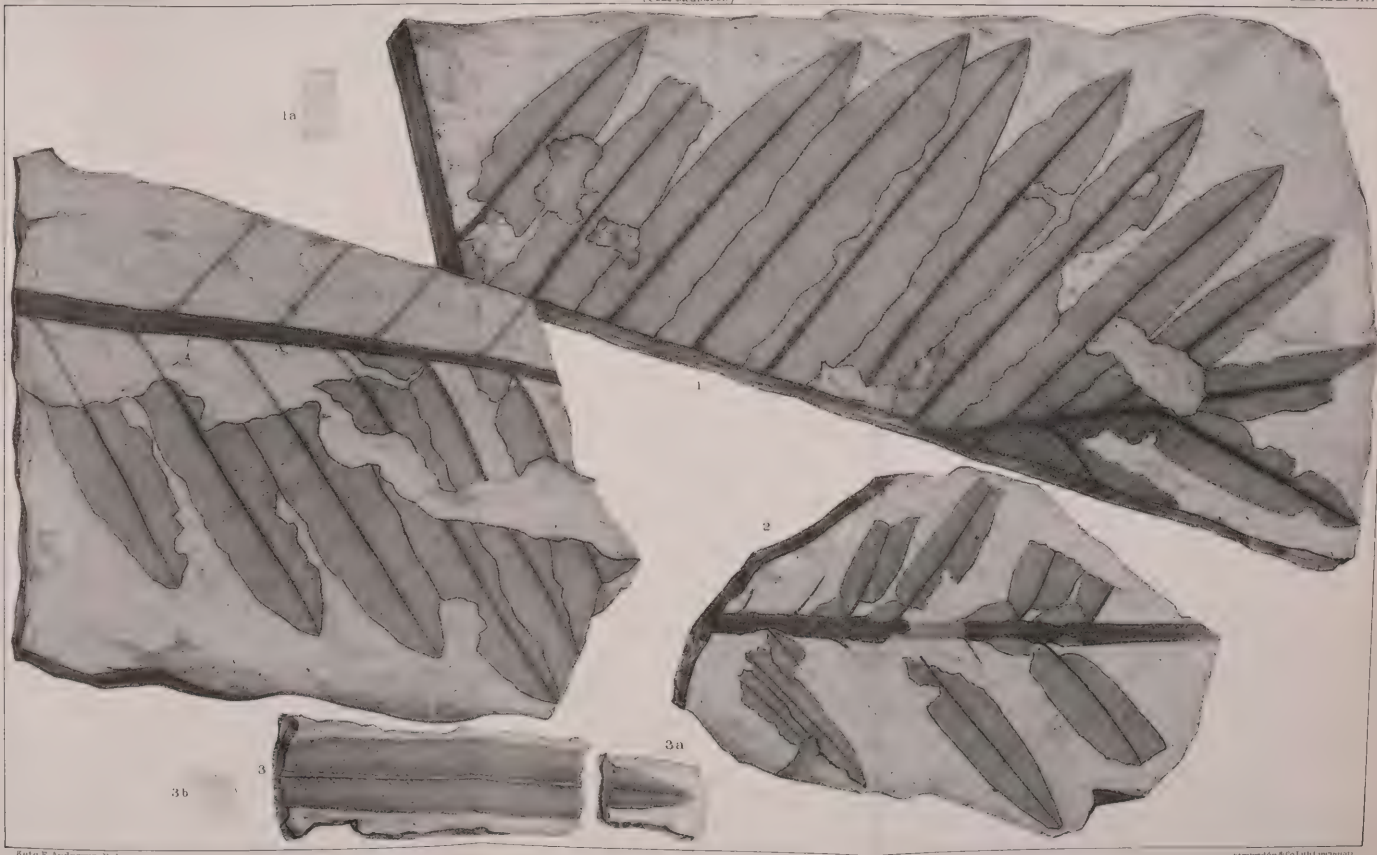
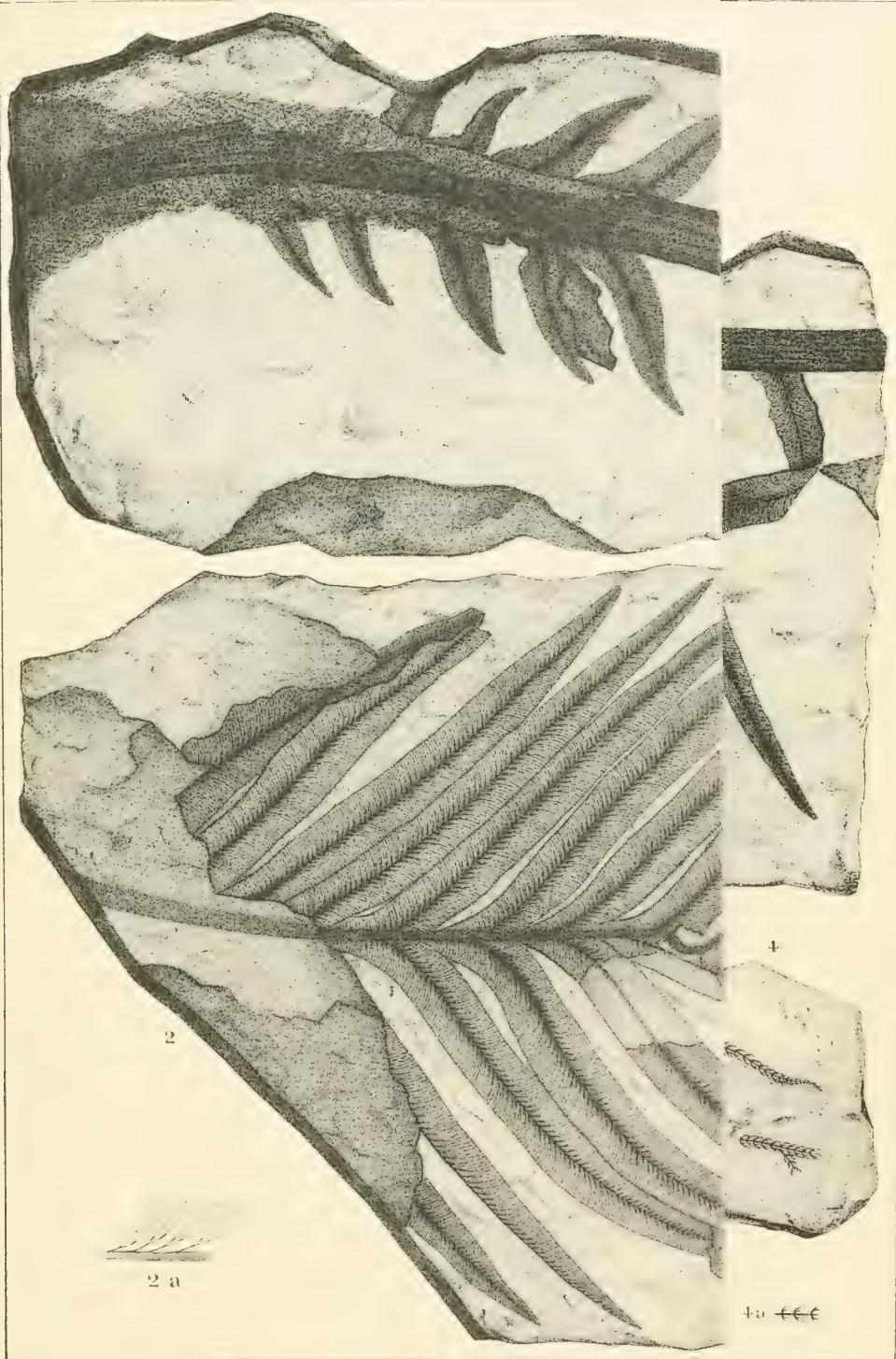


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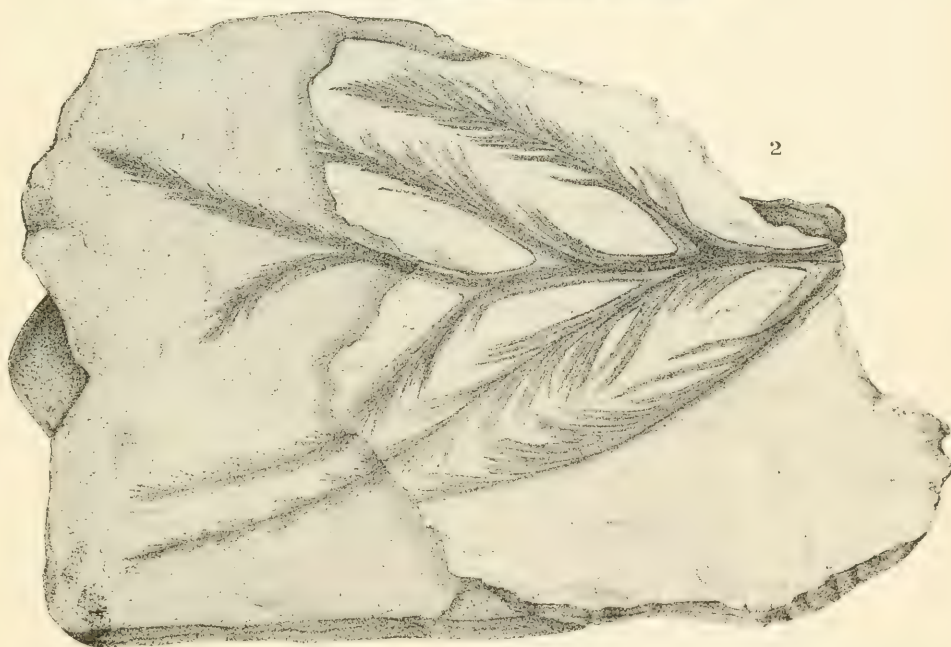
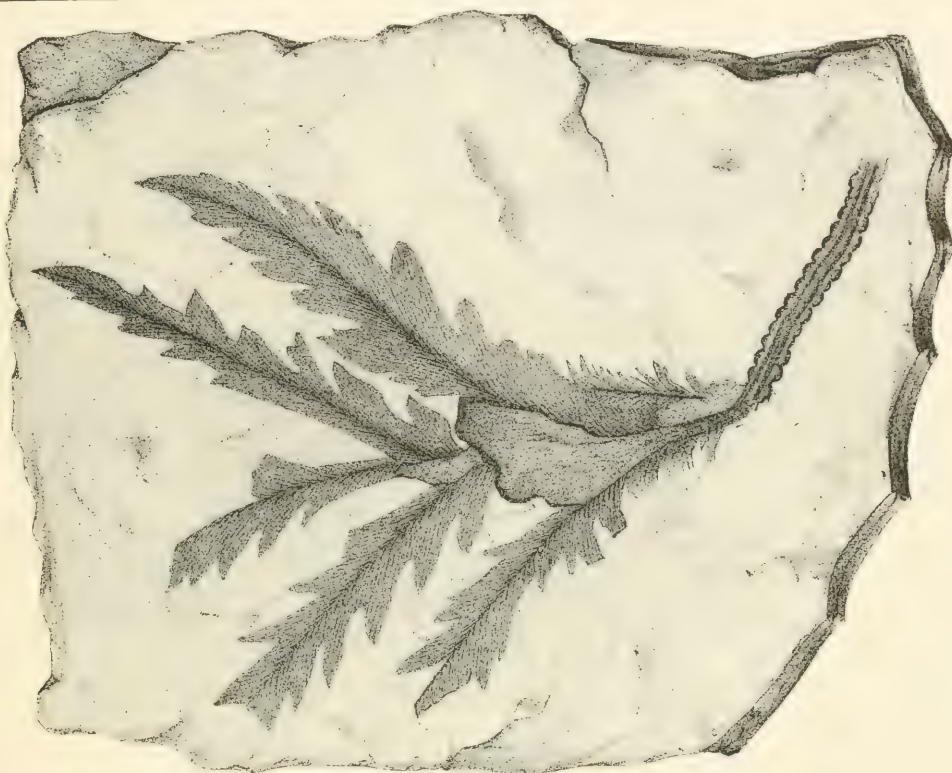


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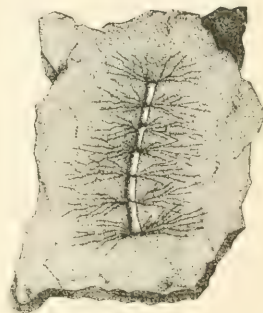
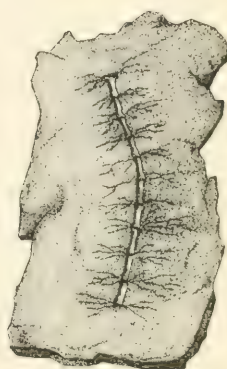
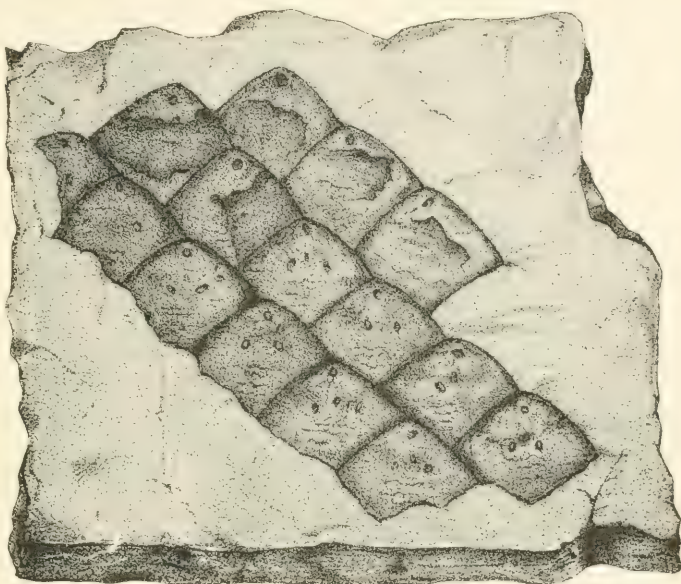


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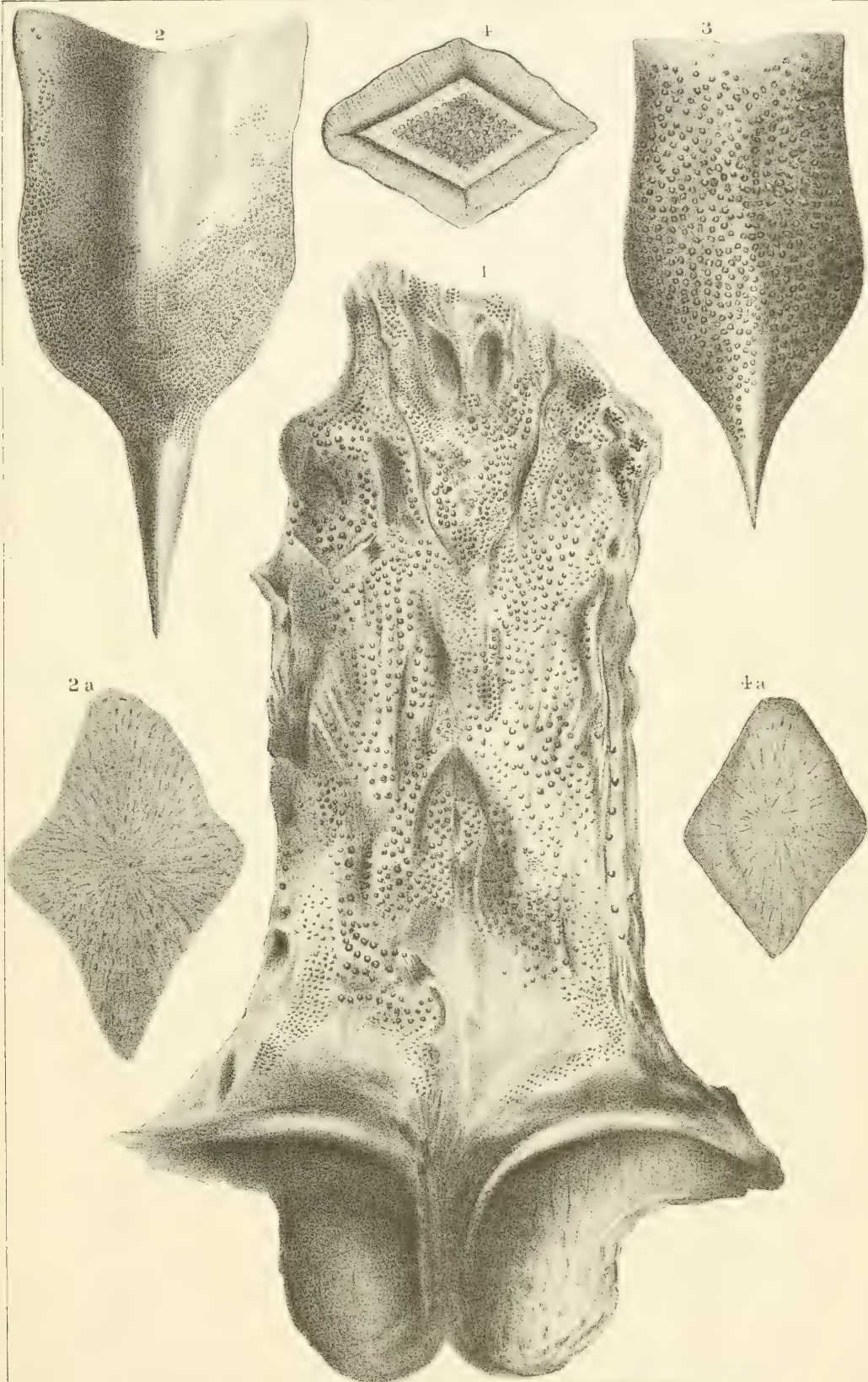


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ACANTHASPIS ARMATUS, Newb..... 37

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 2. Plate bearing spine, from right side of cranium?
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 4. Under side of a plate generally similar to fig. 3, but holding a different position, or belonging to a different species.
 5. Exterior surface of a plate found associated with other remains of *Acanthaspis*.
 5a. Ornamented surface. Twice natural size.
 6. Inside of plate similar to fig. 3, but detached from its spine.
 All figures, except 5a, natural size.
 All originals from the Corniferous limestone, Sandusky, Ohio.

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(Corniferous Limestone)

PLATE IV.

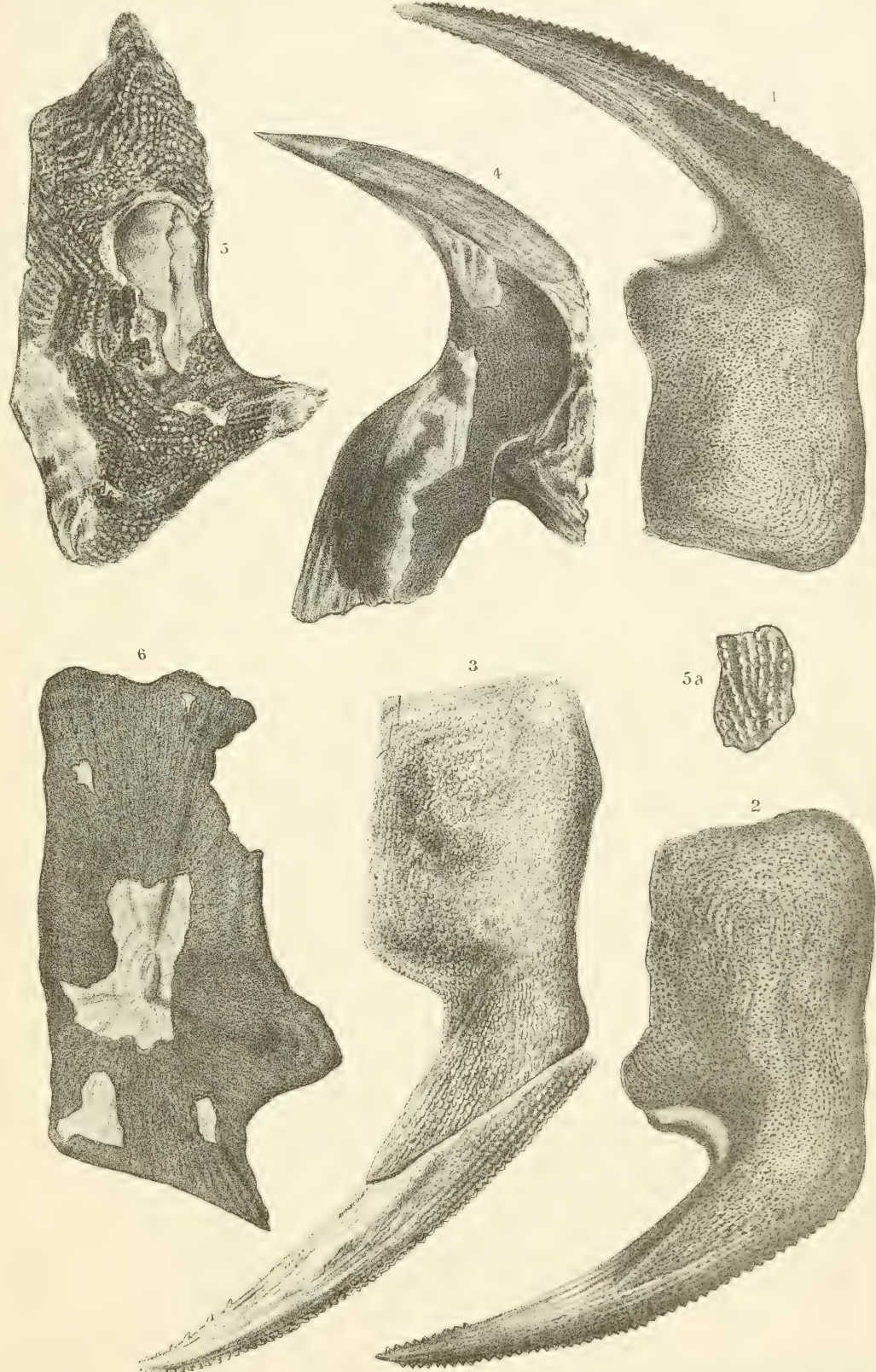


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5. Slender spine, probably from body.	
6. Robust spine, with strongly squamose margin, from body?	
All the figures, except 1 <i>b</i> , are of the size of nature; the originals from the Corniferous limestone at Delaware and Sandusky, Ohio.	

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(Corniferous Limestone)

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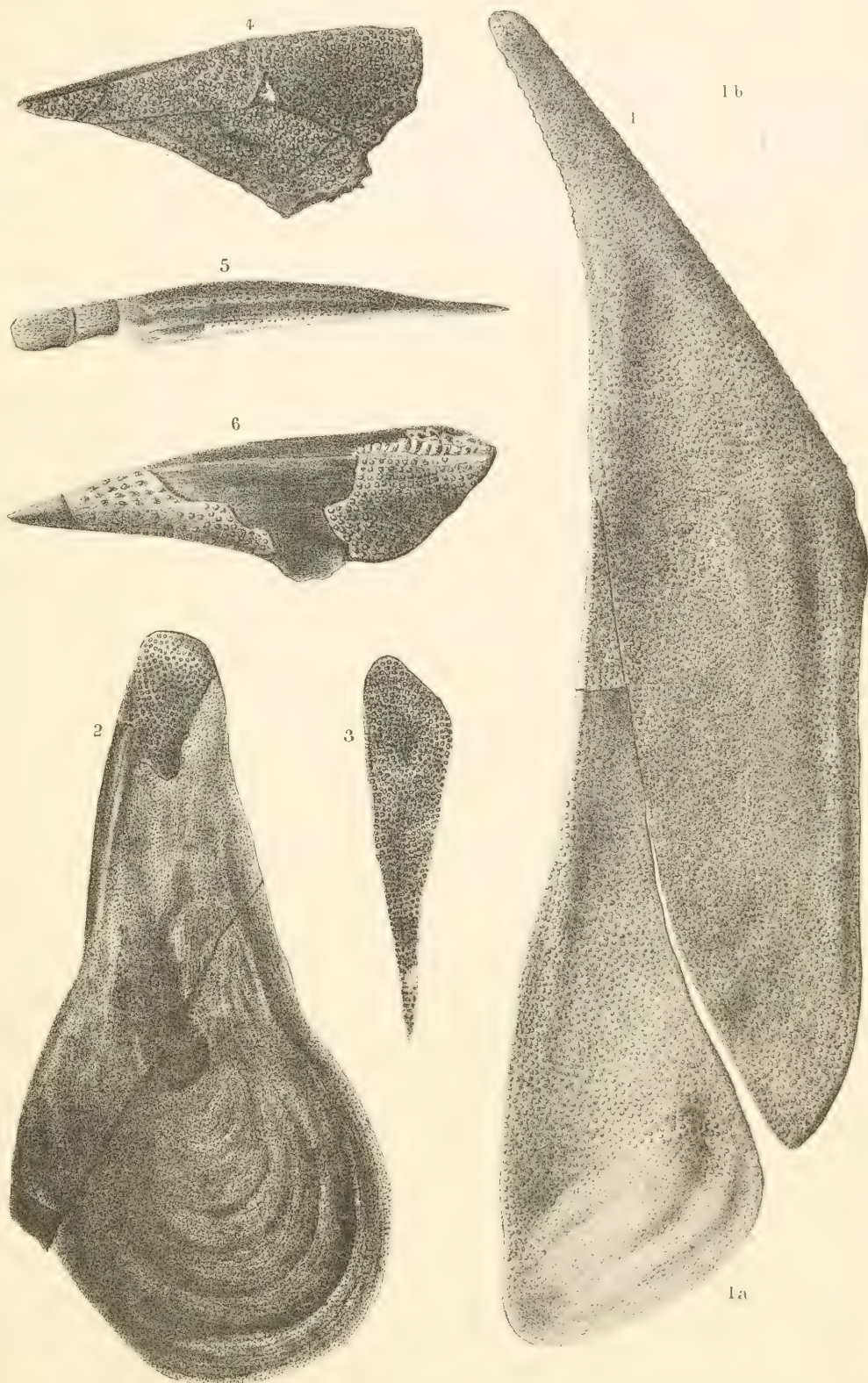


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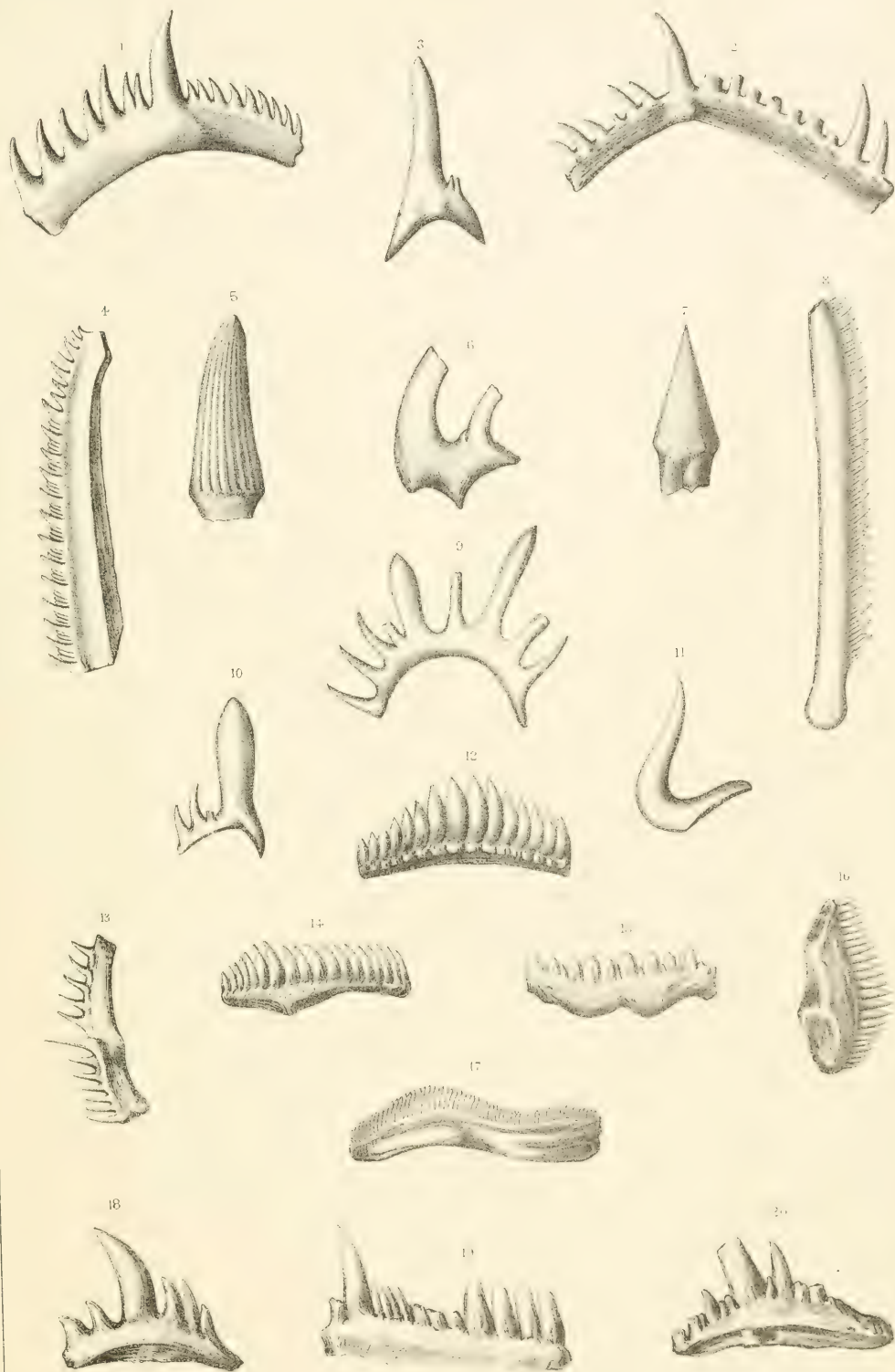


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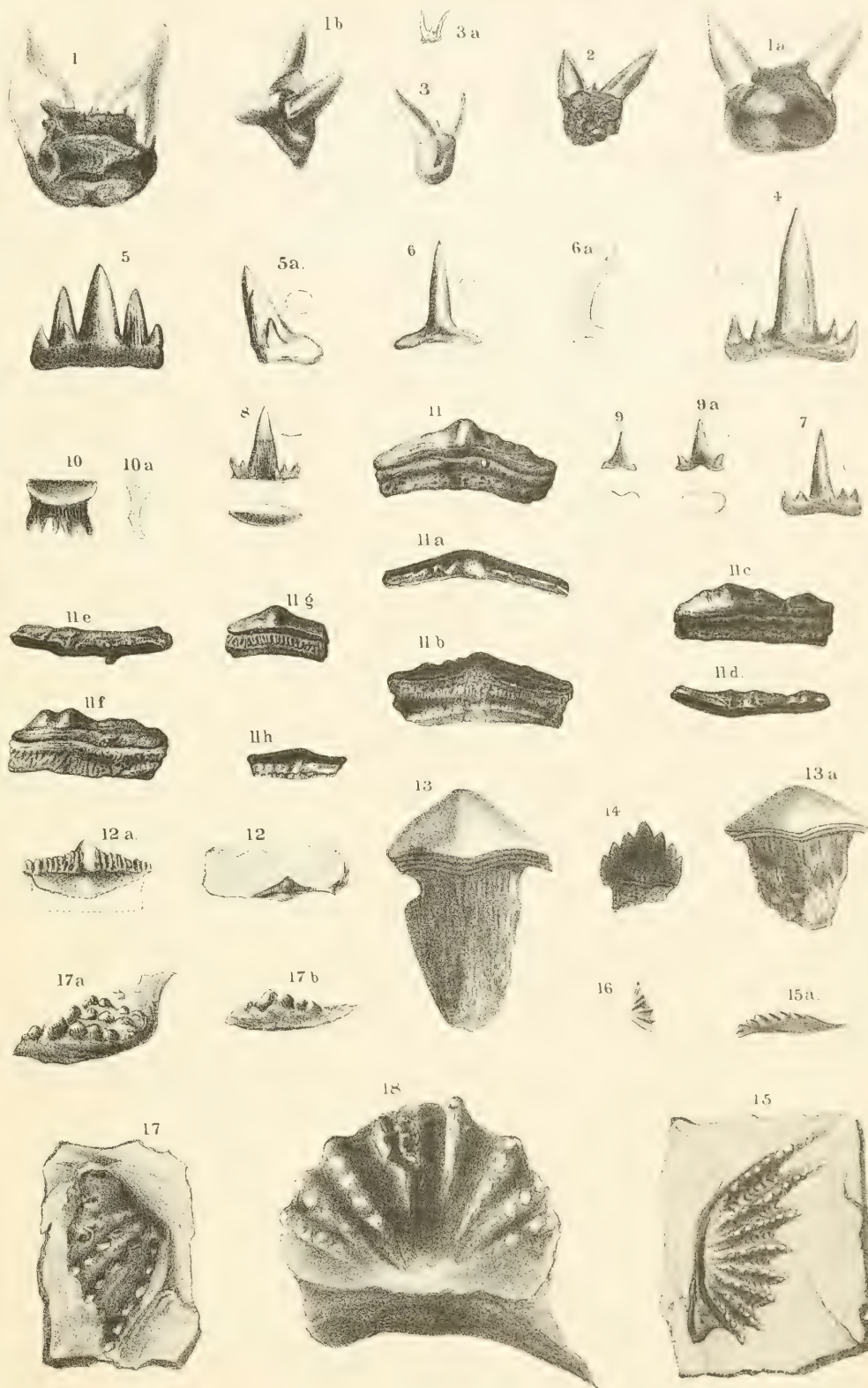
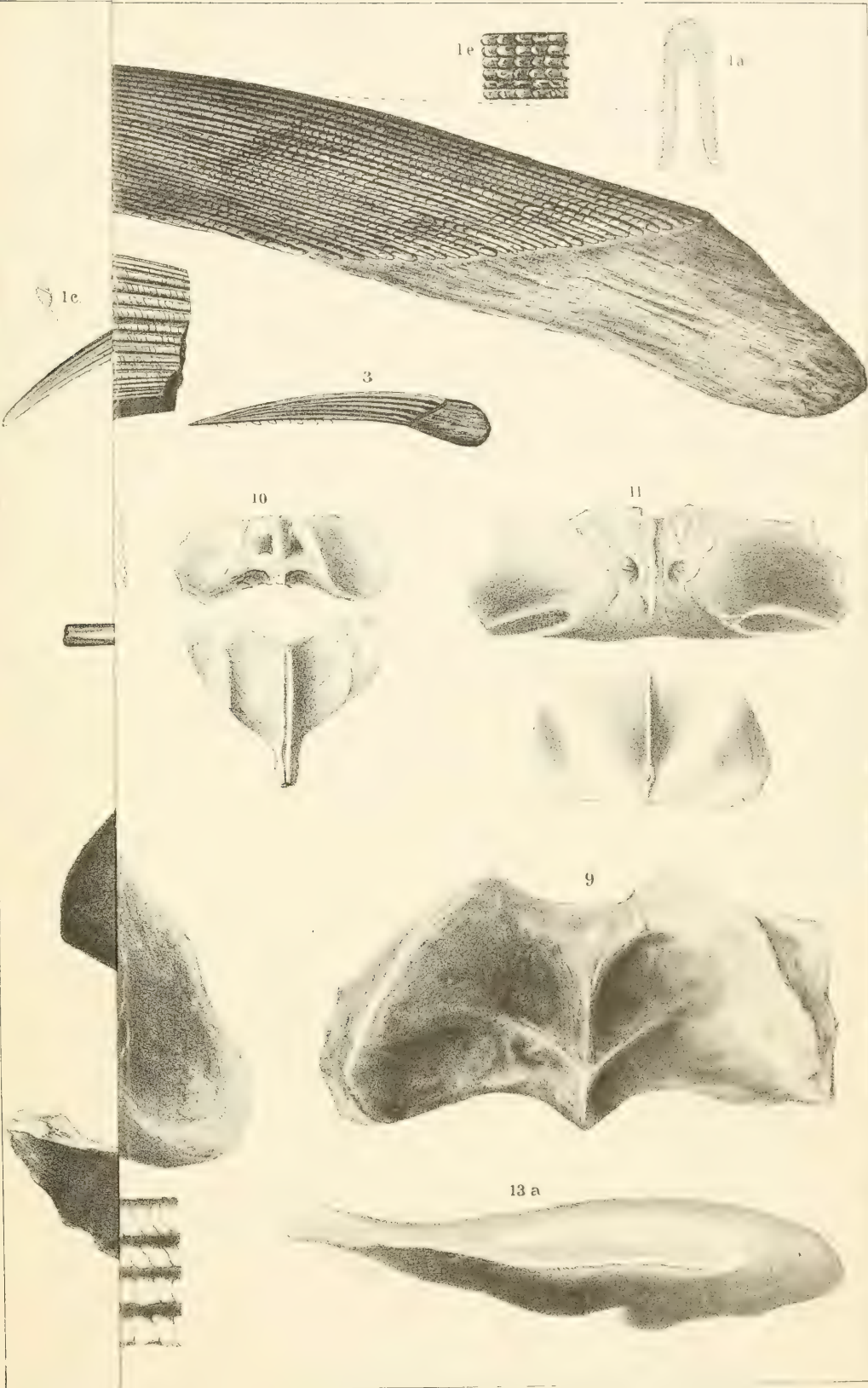
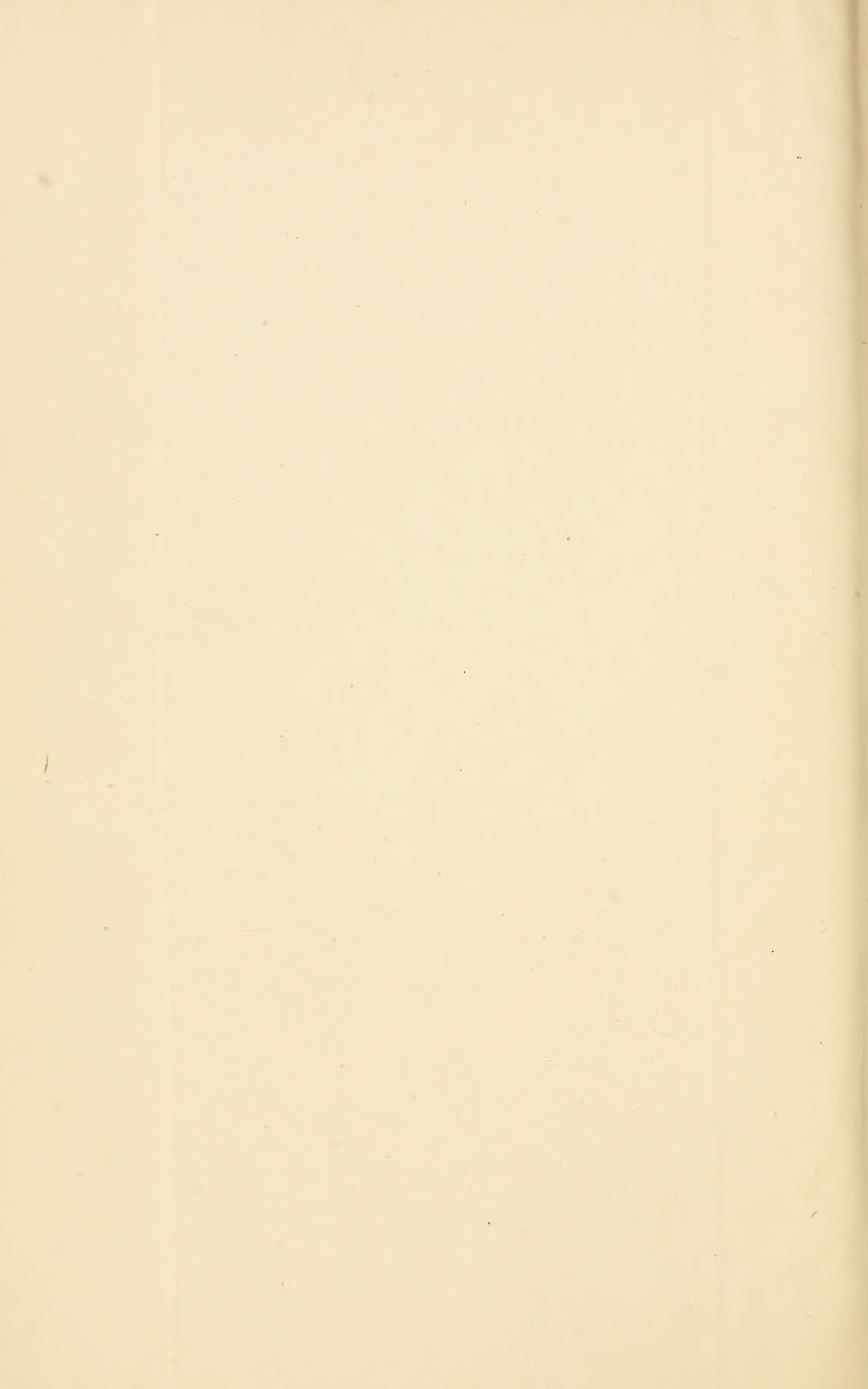


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